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ABBREVIATIONS. — D. = Discussion; I. = Illustrated.
Names of authors are printed in *italics*.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

CATCH-BASIN CONSTRUCTION AND MAINTENANCE.

FOLLOWED BY BIBLIOGRAPHY.

(Topical Discussion presented before the Sanitary Section, November 1, 1916.)

BY GEORGE A. CARPENTER, LEWIS M. HASTINGS, EDGAR S. DORR, GEORGE H. NYE, DAVID A. AMBROSE, PHILIP W. TAYLOR, GORDON H. FERNALD, HENRY A. VARNEY, WM. A. BROWN, EDWIN H. ROGERS, W. L. VENNARD, FRED R. CHARNOCK, WALTER E. NOBLE, JOHN H. GREGORY, FRANK A. MARSTON, AND MISS M. E. EVANS.

MR. GEORGE A. CARPENTER.* — Shakespeare and catch-basin construction may seem to be widely different subjects, but Hamlet's soliloquy has been so often parodied that perhaps one more attempt may be pardoned. At any rate, the speaker thought he saw another application and could not resist the temptation to take his try at it.

Catch basin or inlet, — that is the question;
Whether 'tis better for the mind to favor
The building, care and maintenance of basins,
Or to take arms against this sea of troubles,
And just build gutter inlets? To dare to clean
No more: — and by that act to say we end
The nuisance, and the many natural shocks
These basins give us; 'tis a consummation

NOTE. · Further discussion of this subject is invited, to be received by the editor before March 10, 1917, for publication in a subsequent number of the JOURNAL.

* City Engineer, Pawtucket, R. I.

Devoutly to be wished. To act, — to sleep: —
To sleep; perchance to dream; ay, there's the rub;
For in that peaceful sleep what dreams may come
After we have filled all those old basins
Must give us pause. This is the thought
That makes us hesitate in building inlets;
For who would bear the gibes and jeers of men
Caused through mistake, the proud man's contumely,
The pangs of anxious doubt, results delayed,
The politician's keen, exhaustive search
That patient bides such opportunity,
When he, himself, might his contentment have
By simply building basins?

With most of us, however, the catch basin is here to stay, — at least for some time to come, — and demands regular, systematic inspection and cleaning. How to accomplish this in the most satisfactory and economical way is the problem under discussion.

For years the speaker has worked, on various occasions, to discover some *form* of basin construction that would lend itself to better and more economical cleaning methods, or to originate some more satisfactory way of cleaning the type of basin already constructed. Up to within a very short time, however, he had discovered no method of cleaning that seemed any better than the one quite generally adopted, of sending a man into the basin to shovel its contents into a bucket which is then raised and dumped into a cart by men at the surface. This method has always appeared crude and unsatisfactory, especially the sending of a man into a wet, dirty basin to bail out the water, and work, some of the time at least, in very cramped quarters.

About two years ago men in the employ of the city of Pawtucket developed the idea of combining a power hoist with an automobile truck, for carting away catch-basin detritus, and out of this idea gradually grew the more perfect cleaning apparatus now in use in that city. Before describing this, however, it may be of interest to discuss the form of the basin itself.

When the construction of a sewer system was begun in Pawtucket, over thirty years ago, the type of basin adopted was that shown by Fig. 1. This was the type used at that time in

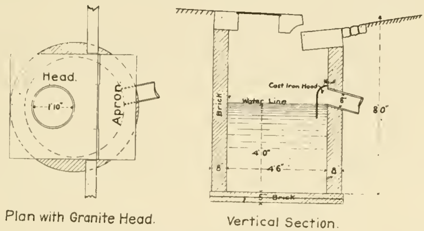

FIG. 1. CATCH BASIN

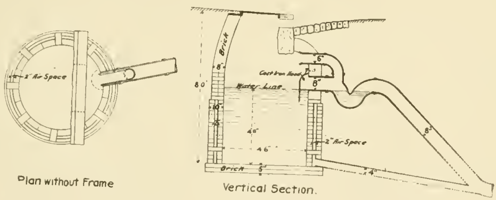

FIG. 2. CATCH BASIN WITH DRAINAGE SPACE

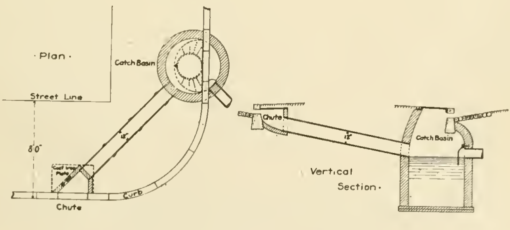

FIG. 3. CATCH BASIN AND INLET

the neighboring city of Providence, except that the Providence basin was built with a stone slab for the bottom, while in Pawtucket the bottom was constructed of two courses of bricks laid flat. This basin was covered with a heavy, granite head and gutter-stone which cost about $25.00 per set and which required the use of a derrick for setting.

An ordinary, oven-door trap was first used to cut off the sewer gases, but this required that the basin be filled with water to the overflow line to be effective. A few years later the Coleman trap was invented and placed upon the market, and was extensively used in Providence, Pawtucket and many other places.

The main claim made for the Coleman trap is the great saving of water used for trapping the basin after cleaning, and its more permanent water seal. It has been the speaker's experience, however, that there are several practical disadvantages which more than offset the economical feature claimed. The inlet to the trap is small and so constructed that small sticks, leaves and other floating matter readily enter and often produce a complete stoppage. Where frozen slush enters a basin in the winter season this form of trap is more easily clogged and less easily relieved than the old oven-door trap which can be yanked open in an emergency and be made to give instant relief to clogged conditions.

As experience brought out these objectionable features they were partially overcome by the addition of a galvanized-iron hood which protected the opening to the trap. Many traps were thus equipped, but so much difficulty was still experienced that these traps were eventually removed and plain cast-iron hoods were substituted. It is only fair to state, however, that these traps are still used and thoroughly approved by the Providence officials.

Most engineers have ideas which they attempt to work out from time to time in an effort to accomplish some specific purpose, and some of the speaker's will be referred to.

In an effort to overcome the objectionable features alluded to, some basins were constructed after the following designs:

A regular S-trap (Fig. 2) was placed in the connection just

outside the basin, and was ventilated into the top of the basin to prevent syphoning. This connection also provided an additional outlet in case of any obstruction at the hood, or where the basin had been neglected and had become filled with dirt to above the hood level. The inlet to the trap was protected from floating sticks and leaves by a hood. The few basins of this type which were built have been in use for a dozen years, or more, and have never given any trouble, so far as the speaker has been able to ascertain by repeated inquiry of the cleaning gang.

Another form of basin (Fig. 2) designed to do away with bailing, and to produce drier material for easier handling, was built as follows:

The two courses of the lower portion of the basin were separated by a two-inch space and the inner ring was built of soft, porous bricks. The space between the courses was drained by a connection to the main outlet pipe of the basin. The inspector of basins informed the speaker, a short time ago, that the contents of these basins were always much drier than the contents of other types of basins and also stated that the S-trap held the water seal much better than other forms of traps. Before indorsing the above opinion, however, the speaker would wish to make a personal inspection and study of conditions.

A great improvement in catch-basin construction was made when Providence adopted, about 1905, a form of cast-iron head and curbstone inlet, which reduced the cost and did away with the heavy granite head and gutter-stone. The speaker considers that, in his observations and experience, he has never found a better or a neater catch-basin head than this (Fig. 3). The inlet is made by cutting an opening through the curbstone, and nothing but a light, iron cover about two feet in diameter shows on the surface of the sidewalk.

Another detail which has proved more or less of a nuisance to the comfort of the pedestrian is the corner basin. In the earlier days an attempt was made to economize by constructing one basin instead of two at sidewalk intersections and locating it at the intersection of the curb lines. This form of construction may have been more economical but it made necessary a

deep gutter through the cross-walk. To-day we avoid stepping across a full flowing gutter by better basin locations and designs.

At sidewalk intersections only one basin is built, as formerly, but this is located above the cross-walk (Fig. 3), and in the adjacent curb of the intersecting street an additional inlet or chute is constructed with a pipe leading under the sidewalk to the basin. It has not been necessary to abandon corner basins already constructed to accomplish the same result. Where they exist and it is desired to improve conditions, the old entrance to the basin can be closed and simple chutes, or inlets, can be constructed on each street and connected, under the sidewalk, with the old basin.

When planning catch-basin openings and connections, the speaker has often felt the lack of sufficient data relative to the approximate amount of storm-water that will pass a given opening in the curb, and also the maximum quantity that will pass the form of trap and connection used. Inlets through the curb, of the form illustrated, generally measure about 4 ins. x 24 ins., 4 ins. x 30 ins. or 4 ins. x 36 ins. as the location seems to demand. Eight, ten or twelve-inch pipes are used for connections between the basin and the sewer, as the engineer's judgment dictates. The speaker raises the question, would it not be well to have more definite data than we at present possess, respecting the relative capacity of various inlet openings, traps and sewer connections? Investigations along this line might be made with profit.

Maintenance.

Unless some systematic inspection of catch-basins is maintained, the cleaning gang may spend its time bailing out three feet of water to remove one foot of dirt instead of attending to those basins only which contain sufficient dirt to warrant cleaning.

A number of years ago the speaker developed a system of inspection and records which enabled written directions to be given the cleaning gang, informing it just what basins to clean, the order in which the work was to be performed and requiring written reports of the work accomplished to be returned to the

office. By this means a record of the work performed, the amount of material removed from each basin and the costs per cubic yard were obtained.

As frequently happens in municipal affairs, however, changes in administration occurred, the newness of the system wore off, it began to run itself and costs began to soar. The story is told of how the cleaning gang at one time developed a method of fooling one of the inspectors employed to see that the cleaning was properly performed. It was the custom of this inspector to drive up to the curb near the basin and ask if it had been completely emptied. Receiving an affirmative reply, he would request that a stone be dropped into the basin and the sound of the stone striking the bottom assured him of the correctness of the report without the bother and exertion of a more careful inspection.

Upon finding this method was becoming a common practice with this inspector, some bright member of the gang evolved the scheme of removing only a part of the contents of the basin and then digging a hole down to the bottom in the center of the remainder. Then, resting from its labor, the gang was ready for the inspector's visit and, when he appeared in sight, was gathering up its tools preparing to depart for the next basin needing attention. Upon being asked the usual question as to whether the basin was cleaned the gang always answered in the affirmative and in proof of its statement promptly dropped a stone into the basin. Going down through the hole excavated in the center the stone stuck the bottom and gave forth the proper sound, whereupon the work received approval and was properly recorded upon the inspector's report cards, which were later sent to the office. Of quite equal value, the speaker imagines, may be many of the so-called *statistics* which engineers review in the course of their work.

During the speaker's experience, he has often had visions of reducing the cost of catch-basin cleaning, and has spent hours trying to work out some form of basin construction which would contribute to this end. His schemes have varied all the way from buckets, or tubs, in the basin, which could be hoisted to the surface when full and dumped directly into a cart, to a small

ladder dredge working through the cover, or through a specially designed opening. All these schemes have ultimately led to the conclusion that any cleaning device, to be practicable, must be adaptable to the present form of basin, as there are too many basins in use to think of general reconstruction.

Pawtucket feels it has recently produced a type of cleaning truck that accomplishes the purpose sought. In its present state it is the result of practical experience on the job, and considerable improvement has been made over the original design. Starting with a simple, self-dumping, auto truck equipped with a power-operated hoist, a water pump and orange-peel bucket hydraulically controlled have been added, and now the city has a machine equipped for the practical and rapid cleaning of basins at a greatly reduced cost.

Catch-Basin Cleaning Truck.

The truck consists of a Standard chassis with a 32 h.p. engine. On this is mounted a steel body made by the Monahan Vehicle Company, of Providence, R. I., which measures about 9 ft. by $4\frac{1}{2}$ ft. by $2\frac{1}{3}$ ft. high and has a capacity of 3.4 cu. yds. Cover plates 2 ft. wide are placed over each end to prevent the slopping of the load. (Fig. 4.) The average load has measured about 2.6 cu. yds. and weighed about 3.4 tons.

The tailboard is hinged at the top, provided with a rubber gasket, and can be clamped tightly against the body. The body is provided with a hydraulic lift operated from the transmission system of the engine. A pair of 6-in. I-beams are mounted on the chassis back of the driver's seat, and on these I-beams is mounted the 2 h.p. Fairbanks & Morse gasoline engine and the cable-drum and control mechanism. The cable runs to an outrigger which can be swung over the catch basin and back over the cart after the bucket is raised and ready to dump. A 4 h.p. engine is to be substituted for the original 2 h.p., as the first engine was found lacking in power for the most efficient work.

The first bucket provided for this truck was a plain, cylindrical one 14 ins. in diameter and 17 ins. deep, with a capacity of $1\frac{1}{2}$ cu. ft. It was filled by hand by a man in the basin, after the manner of the regular cleaning methods then in use. After

operating this equipment from July until November, 1913, an orange-peel bucket controlled and operated by oil under a pressure of about 100 lbs. per sq. in. was substituted. (Fig. 5.) Experiments have recently been made with compressed air in place of oil, which indicate that the time of loading can be materially reduced by this means, and it is probable that compressed air will be substituted for the oil.

FIG. 4. CATCH-BASIN CLEANING TRUCK, PAWTUCKET.

When the truck was first put in operation with a bucket loaded by hand, its average output was 5 loads, or 13 cu. yds. per day of nine hours. With the orange-peel bucket this output was increased to 9 loads, or 23.4 cu. yds. per day. Experiments with compressed air indicate that this can be increased to 12 loads, or 31.2 cu. yds. per day.

In February, 1916, a test was made with compressed air, and the following data were obtained while cleaning four basins. At the first basin 25 cu. ft. of soft material were taken out in

four minutes. The truck was moved to a second basin in five minutes and 50 cu. ft. were added to the load in twelve minutes more. This gave a load of 75 cu. ft. in twenty-one minutes, or sixteen minutes of actual loading time. The truck was then taken to a dump 6 200 ft. distant and returned to a third basin 6 600 ft. from the dump in eighteen minutes, — a rate of 8.07 miles per hour. In two minutes more the truck was located over this basin and took out 65 cu. ft. of hard material in twenty minutes. It was moved 500 ft. to a fourth basin in seven minutes and in four minutes had added 15 cu. ft. to its load and started

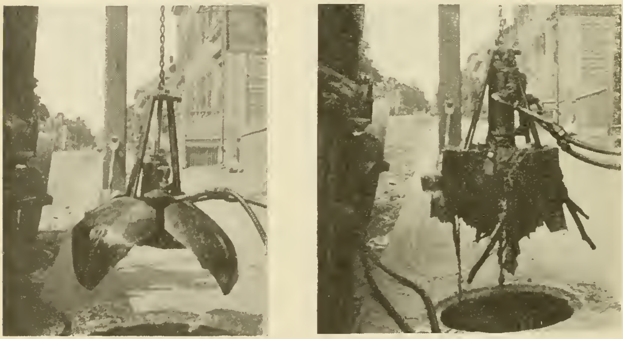

FIG. 5. ORANGE-PEEL BUCKET OF CLEANING TRUCK.

for the dump 6 700 ft. away. It dumped its load and returned to the starting-point in twenty minutes.

The above indicates that 155 cu. ft., or 5.75 cu. yds., were moved to a dump $1\frac{1}{4}$ miles distant in one hour and thirty-three minutes, an average of a load of 2.87 cu. yds. in forty-six and one-half minutes. The average loading time was seven minutes per cu. yd., and the speed to the dump, a little over 7 miles per hour.

Figures made in 1897 gave an average time for loading by the old method of forty minutes per cubic yard and an average time for hauling of thirty-five minutes for 3 500 ft., or 1.13 miles per hour.

It seems reasonable to predict an average of one load of 2.6 cu. yds. every forty-five minutes to a dump $1\frac{1}{4}$ miles distant when the compressed air attachment shall have been made, and, using this figure for an average daily output, 3.466 cu. yds. per hour, we may approximate the total cost per cubic yard as follows:

Approximate Cost per Cubic Yard of Cleaning Basins, Based on a Year of 40 Weeks, or 1 920 Hours.

Overhead Charges.	Cost per Hour.
Interest at 4 per cent. on approximate cost of truck ($4 200.00), or $168.00 ÷ 1 920 =	$0.087
Depreciation and repairs at 20 per cent., or $840.00 ÷ 1 920 =	0.437
Tires — one set of rear tires and one-half set front tires, $250.00 ÷ 1 920 =	0.130
Labor — 3 men at $12.00 per week, 1 man at $16.00 = $52.00 ÷ 48.00 =	1.083
	$1.737
$1.737 ÷ 3.466	$0.50 per cu. yd.
Cost of gasoline ($112.00), oil and grease ($14.70) for 1 474 cu. yds. of actual work = $126.70 or	0.086 " " "
Double this to allow for increase in price =	0.17
Total cost	$0.75 per cu. yd.

The following table represents some of the figures obtained from the older inspection and cleaning methods referred to.

TABLE 1.

Cost of Catch-Basin Cleaning at Pawtucket, R. I.

Year.	Basins Cleaned.	Loads Removed per Basin.	Cubic Yards per Load.	Cost per Cu. Yd.	Average Length of Haul in Ft.	Cost per Cu. Yd. on Basis of Wages Paid in 1915.
1897	1 155	1.84	0.824	$0.765	2 260	
1898	1 694	1.95	0.90	0.70	2 780 ±	
1899	1 233	1.92	0.96	0.66	2 500 ±	
1900	1 271	2.11	1.00	0.68	2 600 ±	
1901	902	2.55	0.74	0.737		$0.964
1902	563	2.53	0.75	0.920		1.07
1903	1 063	2.48	0.72	1.04		1.21
1904–5	1 162	2.20	0.77	1.058		1.23
1907	1 213	2.17	0.817	1.34		1.56
1908	1 404	1.95	0.89	1.55		1.804
1909	992	2.01	0.84	1.55		1.804

MR. L. M. HASTINGS.* — Cambridge has been building catch basins for quite a while — the first of which there is any record having been built in 1850. It might therefore be of interest to trace the progressive steps taken in building the different types from that date to the present time.

Fig. 6 shows one of the older types that were built in the early days. It was built of bricks and "natural" or Rosendale cement with a short curbstone at the sidewalk line and a granite "bar stone" forming a trap or water seal. The top opening had a stone frame in which was set a 3-in. oak cover 2 ft. 4 ins. square. The bar stone was set across a little alcove or extension of the basin from which the outlet led to the sewer.

These basins were elliptical in plan, being about 6 ft. in longitudinal diameter and 5 ft. transversely, and 7 ft. from curb to the bottom, holding about 3 ft. in depth of material. The throat or inlet was cut in the face of the curb and was about 20 ins. long. There were many objections to this type. The covers, being of wood and in the gutter, decayed rapidly and were a constant source of danger to horses and of expense for renewals; also the water often froze in winter and it was difficult to free the outlet of ice. Then, again, if the outlet got choked with sticks or rubbish, it was very difficult to get at it to free it of obstructions, so that on the whole they were unsatisfactory. To obviate the difficulty of the old wooden covers, we introduced a few of the covers called "Concord grates." It was a pretty good grate in many ways, having an annular opening near the edge which created a whirling motion in the water, tending to keep it from clogging with leaves, rubbish, etc.

One great difficulty with all these basins is, not that they do not have capacity enough when running clear, but the great likelihood of clogging at the inlet. The problem is largely one of keeping this clear. This we have found the principal difficulty in Cambridge.

There was still another type of top, a square iron grate set in the old stone frame. This is an improvement on the wooden cover but it was found that it was liable to be thrown out of its seat by the passing of wheels or by a horse's foot, so that about

* City Engineer, Cambridge, Mass.

1870 another type was introduced. In this type the inlet is in the curb, but the top opening and its cover is in the sidewalk, so the gutter is clear. That was a great improvement and much safer. These were large and expensive basins, the heavy granite top adding a good deal to the cost, which was about $150.00 each. In order to reduce the cost somewhat, another type was then tried, using the ordinary curbstone for the front, and making the top of North River flagging stone.

Now, after passing through these stages, in the 1880's, we adopted the type shown on Fig. 7, and it is practically the type we are using now. The body or pot is round, 5 ft. in diameter

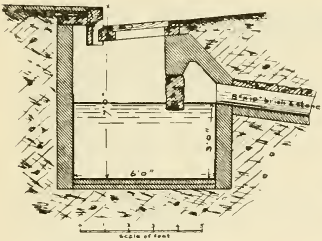

FIG. 6. OLD TYPE.

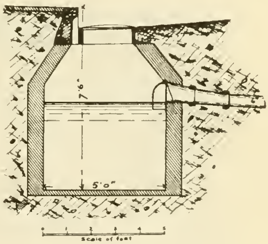

FIG. 7. PRESENT TYPE.

CAMBRIDGE, MASS.

with the bottom 7 ft. 6 ins. below the curb. Instead of the granite bar stone, we use a modification of the " Boston trap," made of cast iron with a hood in front, which keeps the débris from passing into the outlet and making trouble, and it also gives it a water seal. It also has a metal valve opening outwards toward the sewer, so that, if the water in the basin gets low and below the hood, sewer gas will not come back into the air.

We have tried various styles of hoods and traps, but have always come back to that, as about the best thing. The average cost of this type of basin has been about $75.00, including the outlet to the sewer. On the top or opening, we now use, instead of the wooden cover or square iron grate, what is called a D-frame and grate, placed in the gutter. It is made in the shape

of the letter D, with a heavy iron frame and a perforated grate which is locked into the frame.

Behind the frame, a slot or throat is cut in the face of the edgestone, making two opportunities for the water to enter. This frame and grate weighs about 650 lbs. and costs about $12.50 per set. The iron trap costs about $5.00. The average cost of the stock, castings, brick, cement, trap, pipe, etc., is $40.00, and the cost of labor $35.00. The grate, frame and trap, with the hood thrown back, are shown in Fig. 8.

We find in Cambridge that one great difficulty with any grate is the liability to clog in time of storm. That is the reason

Fig. 8. Trap, D-Frame and Cover.

for having the throat in the curbstone. But, even with that, it is not unusual for all openings to be completely sealed up with rubbish, with resulting flooding and damages.

Recently I have tried the expedient, where the basin is located in an unfavorable situation, of placing at a short distance away from the regular basin, say ten feet, another grate with a connection to the regular basin, thus making a double inlet. This has worked very well. The outlets of our basins are made much smaller than is usual, I think. They were at first built of brick 8 ins. by 12 ins., then of 10-in. pipe, then 8-in. pipe, and now we are using 6-in. pipe. I have never heard of an outlet being stopped up yet on account of its small size.

We have about 2 260 basins in the city, and it is an expen-

sive job to keep them clean. The excavation and transportation of the material are the important things. In Cambridge, the excavation has been done by hand labor by city men. It is very difficult to get any place to dump the material without making a long haul. It is now taken and dumped in some old clay pits in the western part of the city, making some of the hauls from two to three miles, which means, of course, a greatly increased cost.

In the "operating end" of this work we have carts with steel bodies and wooden running gear, and others entirely of wood. Two gangs, each consisting of four men and two horses, are employed. While one team is off to the dump with a load, the other is loading. A convenient rig, used for general handy work in attending the catch-basin and sewer-cleaning gang, consists of a small automobile with a light trailer attached. The little trailer carries about a half-ton load and is a very handy machine.

In Table 2 is shown an analysis of costs of the work done by the city in cleaning catch basins from 1905 to 1916, eleven years, and it is interesting as showing the progressive increase in the cost of cleaning. Column 6 shows the total amount expended for cleaning in the periods stated, the period 1908–9 being sixteen months. It will be noted that for the first nine years the yearly expenditure was about $6 000, while for the last two years it was $7 500. In Column 2, it will be noted that the number of basins cleaned decreased from 2 340 in 1906 to 1 128 in 1915–16. This brought the cost of cleaning per catch basin from $2.80 in 1905 to $6.48 (see Col. 7), and the cost per cubic yard from $1.55 to $3.00 (Col. 8). This is explained partly by the increase in wages of the men. In 1912, their pay was raised from $2.00 per day to $2.25, and in 1914, it was raised again to $2.50, with fewer hours of labor per week. I think, however, a larger factor is the constantly increasing length of haul to the dumps. This increases the cost of transportation and also tends to reduce the effectiveness of the men by making longer waits.

In 1915, a careful test was made to determine the cost of long hauls. The gang consisted of four men and two teams.

They cleaned out five basins in two half-days. The dump was two miles off. They took out 5.40 cu. yds. at a cost of $13.00. This made the cost, without any overhead charges, $2.40 per cu. yd., or $1.20 per yard-mile. We are looking for some practical means by which this cost can be reduced.

TABLE 2.

City of Cambridge, Sewer Department, Catch-Basin Cleaning.

Date.	No. of C. B. Cleaned.	Quantity.			Cost.			
		Total Loads.	Loads per C. B.	Total C. Y.	Total.	Per C. B.	Per C. Y.	
1905	2 169	5 213	2.40	3 909	$6 089.69	$2.80	$1.55	
1906	2 340	5 609	2.82	4 206	6 060.54	2.58	1.44	
1907	1 948	4 704	2.40	3 528	5 070.78	2.60	1.44	
1908-9	2 742	5 906	2.15	4 429	8 090.67	2.95	1.82	16 months.
1909-10	1 874	4 157	2.22	3 118	6 732.10	3.32	2.16	
1910-1	1 672	4 181	2.50	3 135	6 225.35	3.72	1.98	
1911-2	1 466	3 676	2.51	2 775	6 344.19	4.33	2.30	Sept., 1911, pay raised to $2.25 per day.
1912-3	1 438	3 463	2.41	2 598	5 656.11	3.93	2.18	Total no. of C. B., 2 068.
1913-4	1 479	3 802	2.58	2 851	6 223.11	4.21	2.18	
1914-5	1 335	3 862	2.89	2 896	7 559.68	5.66	2.61	Oct., 1914, pay raised to $2.50 per day.
1915-6	1 128	3 247	2.88	2 436	7 309.71	6.48	3.00	Total no. of C. B., 2 129.

Mr. Edgar S. Dorr.* — I have two or three designs of standard basins to show you and some figures of cost. Fig. 9 shows one of the standard basins in the city, similar to the one that Mr. Hastings has just shown, with a grate in the gutter, and a gutter mouth. This grate is now generally made square. I think we invented the D-grate, and have rather abandoned it now and substituted the square grates, principally for the reason that they are much easier to pave against. The principle is just the same. Our basins are also larger than any that have been shown, being 9 ft. deep. The big feature is the flap valve

* Office Engineer, Sewer Service, Dept. of Public Works, Boston, Mass.

to be raised in order to let the water off when the basin is plugged and in order to facilitate cleaning. Our basins in Boston have been cleaned by contract for several years, and while we had the ordinary hood trap almost universally, which is hinged at the top and made to be pulled up in order to free the basin, we found a tremendous amount of leakage. If it were frozen or stuck a little bit, it was so much easier for the contractor to smash it than raise it that that was what he usually did. This design was made to overcome that. Where basins are cleaned by day labor, I don't think that difficulty would occur.

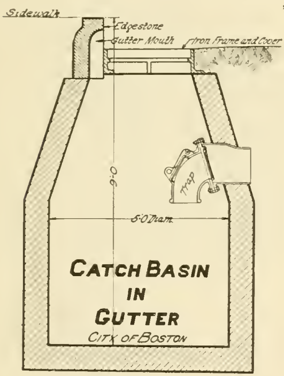

FIG. 9.

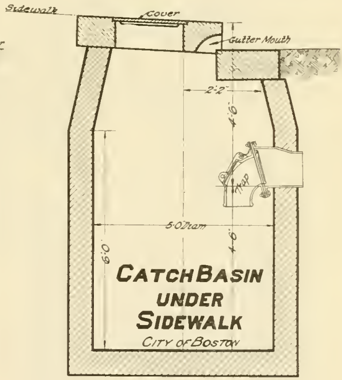

FIG. 10.

Fig. 10 illustrates a basin of about the same size located in the sidewalk. It is called in Boston the "Bradley" basin, with the heavy granite head, gutter mouth and gutter stone. It has the same general dimensions, 9 ft. depth and 5 ft. diameter, and is represented with the same trap. This trap is detachable, that is, the castings are furnished with flanges and are put together with bolts, so it is quite easy to take it off if it does get smashed. I think that is a good trap.

A basin which is a proposition of my own is shown in Fig. 11. It has never been built, and I put it in here to-night merely to start discussion. The great trouble in cleaning basins mechani-

cally is the presence of sticks, wires, broken bicycles and that sort of thing which the people, especially in the poorer districts, appear to take delight in packing into the basins. This makes it almost impossible to clean them by mechanical means.

There is another abuse of basins probably not peculiar to Boston, and that is the piling into the basins of dry material from the streets by the street sweepers. That is sometimes carried

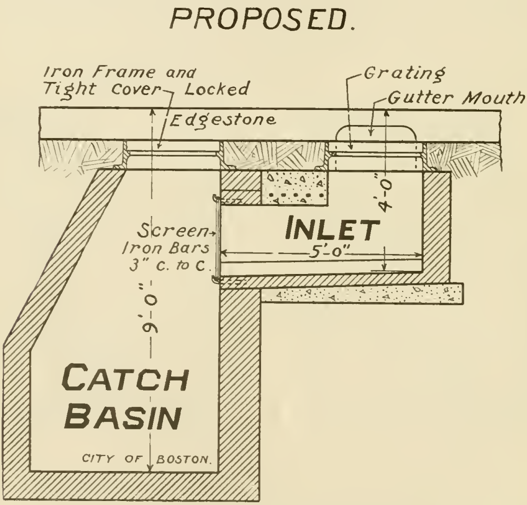

FIG. 11. BOSTON.

on to a very large extent, and at other times not much. We have in many cases found basins which had been cleaned a short time before, filled with dry material, and no rain had occurred in the interval, so there was no question as to how it got there. Now, the idea is to take the gutter mouth from directly over the basin, put in the closed cover if it is in the gutter and a locked cover also, shift the gutter mouth a little to one side and make a kind of vestibule. In that way sticks could not be put in. Wires

TABLE 3.

DATA ON CLEANING CATCH BASINS IN BOSTON, MASS.

Date.	Total Cu. Yds. Removed.	*Total Cost to City.	No. of Catch Basins Cleaned.	Average Yds. per Catch Basin.	Contractor's Price per Catch Basin.	Amount Paid for Inspection.	Average Cost to City per Catch Basin.	Amount Paid to Contractors.
1914–15	25 973.90	$38 147.91	7 775	3.34	$3.61	$7 789.26	$4.82	$30 280.12
1915–16	32 378.49	40 365.35	9 970	3.25	3.01	7 831.35	3.99	32 450.35
1916–17	In progress				2.29			

* *Note.* These figures include everything in connection with the cost of cleaning catch basins.

DUMPS.

South Boston, at McNary Park.	Average haul	= $1\frac{1}{2}$ miles.
East Boston, at E. Bos. Land Co.	,, ,,	= $1\frac{1}{2}$,,
Charlestown, at Everett Dump.	,, ,,	= 1 mile.
Brighton at Faneuil and private.	,, ,,	= 1 to 2 miles.
W. Roxbury, at Washington Street and at Nawn's Dump.	,, ,,	= 2 miles.
Dorchester, at Mills St. Dump.	,, ,,	= 1 mile.
Dorchester, at Codman St. Dump.	,, ,,	= $1\frac{1}{2}$ miles.
South of Dover St., at McNary Park.	,, ,,	= 2 to $2\frac{1}{2}$ miles.
North of Dover St., † Kemp Street.	,, ,,	= 2 to 3 miles.
Hyde Park, lot of dumps.	,, ,,	= $\frac{1}{2}$ mile (?).

† *Note.* There is a private dump at the Fort Hill Dock, but the charge is exorbitant and the contractor will not pay it.

could be, but would be arrested by a coarse screen of round iron bars probably 3 ins. on centers. The street sweeper could pack in perhaps a bushel or two of material, and that would be all. The material that did get in the basin could be removed by some form of mechanical basin cleaner. How that would work out I don't know, but I think it would work well. The filling of this up with material from the streets would of course result in a plugged basin, and there would be many complaints in consequence, and it seems to me the result would be to prevent this practice. We have tried to find some form of mechanical cleaner but haven't met with any great amount of success. We tried a while ago, as Mr. Hastings did in Cambridge, a suction device called the Otterson.

The record of the costs of catch-basin cleaning in Boston for the last three years is given in Table 3.

There is only one more thing I can call your attention to, and that is the matter of the length of haul. Our length of haul runs from a mile and a mile and a half up to two and a half and three miles. That is a very serious matter. It seems to me that is bound to be the case everywhere. If you have a short haul it is soon used up and you are bound to have a long haul, and the conclusion to be derived from that is, in my opinion, that any form of mechanical catch-basin cleaner should be so designed that the expensive machine can be kept at work loading the material into other carts which can be kept running to the dump. The suction machine worked very well on basins filled with mushy material, but it wasn't economical for the reason that as soon as its load was up it had to go to the dump. More time was spent running to the dump and back than in cleaning the basin. This would be the case with all arrangements of that kind.

George H. Nye.*—As the catch basin is the connecting link between the streets and the drainage system, and its only function is to remove the water from the streets and deliver it to the sewers in a proper manner, no description of the basins would be complete without a consideration of the streets and the sewers.

* City Engineer, New Bedford, Mass.

In the seventies, the streets in New Bedford consisted almost entirely of what are known as gravel roads, i. e., the natural loam with the sod removed, crowned up in the spring and down in the fall and winter. The main streets were paved with cobbles. There was, however, a very large amount of flagstone sidewalks with quarry faced edgestones, usually in short lengths. The gutters were cobble paved and deep, and extended across the intersecting streets, with cross-walks which were usually constructed of two lines of flat stone, each about 18 ins. wide, for the use of pedestrians. With this construction every vehicle crossing an intersecting street encountered two very pronounced "thank-you-marms" in its passage. There was also a deep gutter between the curb and the end of the crossing stone, which was been the cause of many bad falls.

These conditions were produced by what seems to have been a very strange catch-basin practice. At that time the catch basins were usually located at a considerable distance above the street corners, in some cases even near the top of steep hills where they were to take the water from cross streets, while the water collected on the steep hill was frequently carried for several blocks across intersecting streets.

A catch basin at that time consisted of a rectangular basin or receptacle, under the roadway, built of brick with stone sills and 2-in. plank set in a rabbet in the sills. A narrow neck extended for about a foot under the sidewalk, and a piece of flagstone set vertically under the curb served as a sort of trap. The opening in the curb was about 4 ft. wide and from 6 to 10 ins. deep, covered with a piece of flagstone which usually formed a part of the sidewalk. The basin was connected with the sewer by a pipe through the nearest wall. The basins held about three cubic yards of sand, and were cleaned through the opening in the street. This type of basin has now been almost entirely replaced by a modern one, as it broke into the street surface, the wooden cover was weak, and the basin occupied the location usually allotted to the underground conduits of the public-service corporations.

At that time the number of basins in a given distance was very much smaller than at present. I recall one case in which

1 500 ft. of gravel street was drained by a single basin. The nature of the street surface was such that the water from a heavy rainfall was much retarded in reaching the sewers. As our heavy rains seem always to occur in showers lasting perhaps five to seven minutes, this retarding of the run-off by its long route and the nature of the street surface reduced by a very material amount the maximum load which might have been put on the sewer system.

During the eighties, a movement for better streets resulted in the rapid building of macadam roadways, and this at once showed the desirability of eliminating the cross gutters at the street intersections. From this followed the policy of building catch basins at the low corner of each block, which is our general practice to-day.

At that time the basin was usually placed with its opening centered on the diagonal of the intersection. This was undesirable for several reasons. The opening was unduly prominent and unsightly, was in the line of travel, and the pitch of the basin in slippery weather made it somewhat of a danger. Worst of all, however, the currents of water in the gutters, flowing in opposite directions, met at the turn, and the centrifugal force at times of heavy rain caused more water to be thrown out over the crown of the street than entered the basin.

The basin of that period was constructed of brick with a flagstone and cement bottom, a 10-in. $\frac{1}{4}$-bend trap and outlet, and flagstone cover about 5 ins. thick and 5 ft. square. The basin was set partly under the walk, and the cover with its front edge cut to the radius of the corner, usually 8 ft., formed a part of the sidewalk. A circular hole, 2 ft. in diameter, was cut in the center of the stone and fitted with an iron cover giving access to the basin for purposes of cleaning and repairs.

With the advent of the basins placed at the low corners of the block, the cross gutters disappeared, but the stone cross-walk still held its place. As the streets gradually became better, however, the roughness of these crossings became more noticeable, and tar concrete, shaped to conform with the macadam, was substituted. These, of course, proved unsatisfactory as they were either too soft or so hard that the concrete crumbled in cold weather.

The present practice is to discontinue the use of cross-walks altogether, and this has proved very satisfactory.

The type of basin which we are at present using (shown in Fig. 12) is 6 ft. inside diameter and 6 ft. deep. The bottom is constructed of concrete in which, before it is set, the concrete blocks of the sides are bedded. The concrete blocks for the sides are 16 ins. by 8 ins. by 5 ins., and are manufactured in molds at the city yard. These sides are carried up to within

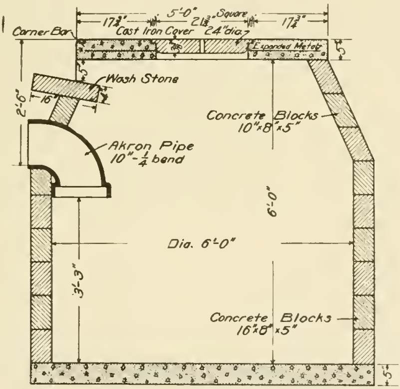

FIG. 12. NEW BEDFORD.

three courses from the top, when specially beveled blocks 8 ins. by 5 ins. by 10 ins. to 11 ins. are used to reduce the size to receive the cover. The cover is constructed of concrete by our own force and is 5 ins. thick and 5 ft. square, made of concrete in the proportion of 1 part Portland cement, $1\frac{1}{2}$ parts sand, $1\frac{1}{2}$ parts pea stone, with the addition of about 2 qts. hydrated lime to each bag of cement, reinforced by expanded metal, and the upper front edge fitted with a corner bar. There is a circular hole in the center, 2 ft. in diameter, fitted with an iron cover for cleaning purposes. The concrete cover rests on the basin and on two 6-in. notches cut in the adjacent curb. The inlet is fitted with a concrete wash stone 6 ft. by $1\frac{1}{2}$ ft. by 4 ins. set with

the gutter, and the trap and outlet consists of a quarter bend of 10-in. Akron pipe from vertical to horizontal. The basins are located with the end 6 ins. on to the end of the curved corner curb and extending in the direction of the straight curbing. The inside of the front edge of the basin is set 6 ins. in front of the straight curb, and the basin is usually placed to face on the street having the steepest grade in order to prevent a rush of water around the corner along the line of foot travel. In case the gutters on both streets have a heavy flow of water, the basin is placed facing on one of the streets and the same type cover or inlet is placed on the other street, with a funnel-shaped chamber slightly deeper than the gutter and ending in a pipe connected with the basin. This arrangement removes all the water from the line of travel and I think is the most satisfactory method of surface water removal that we have.

In the few cases where we have important crossings and no sewer, we have constructed an inlet as above described and connected it by a pipe with a similar structure on the low side of the crossing which discharges the water into the gutter on that side. In these cases we make no attempt to remove the street wash.

The cost of our catch basins averages about one hundred dollars. This includes the cost of drains as well as the excessive cost of some basins constructed in ledge. The cost varied during the last year from $30.55 to $145.93.

The basins are cleaned about twice a year, although certain areas require attention more frequently. The method of cleaning is by shoveling out the contents on to the street surface and removing it to dumps by teams.

The number of basins now in use is 1 526, and the cost of cleaning is about $2.50 each. The average haul is not less than one mile.

At the present time, with 187 miles of accepted streets, there are practically no cross gutters at street intersections on any of the improved streets. While this method of carrying the surface water has resulted in a very satisfactory condition of the streets, another phase of this subject has now been forced on our attention. With nearly all the streets laid with modern

pavement or macadam coated with Tarvia, with more congested building, and with catch basins at every low corner, which are drained by a combined system of sewers, we are experiencing considerable trouble from the flooding of cellars during every heavy rainfall. The sewers, when built, were not designed for such a quick run-off, and are now found in many cases to be of insufficient capacity.

The solution of this problem for us will probably be the gradual construction of a separate system of sewers, utilizing the present sewers for either surface or sanitary sewage as circumstances may determine. If the buildings are disconnected from the present sewers these would in many cases be of sufficient size to care for the run-off, operating under a slight head. In extreme cases, even if the water were not removed from the street at once, no real harm would be done. A heavy downpour seldom lasts over five minutes, and the heaviest of which we have any record over a considerable period of years was at the rate of 6 ins. per hour for seven minutes, and occurred in July, 1915.

David A. Ambrose.* — Our standard catch basin differs to some extent from the city of Boston basin. The type which we have constructed for several years is shown in Fig. 13. The floor is of 2-in. spruce plank or of concrete. Plank is perfectly satisfactory and is easily laid where water is encountered during construction. The basin is 7 ft. 6 ins. in height from the floor to the casting, 4 ft. in diameter in the clear, and 4 ft. from the floor to the outlet. The trap is a casting having a lip embedded in the walls of the basin and a dome-like hinged cover. I believe it was originally called the Carberry trap. The walls of the basin are of brick or concrete. It has been specified at times that the contractor may have the choice of constructing either of brick or of concrete, and the choice has usually been to use brick.

Our standard frame and grate is 8 ins. in height, and the grate is 24 ins. in diameter, substituting the D type for the dished grate when the casting is installed against an edgestone.

* First Asst. Engineer, Metropolitan Park Comm., Boston.

An opening is cut where the D-frame comes in contact with the edgestone. We use more of the former type, as most of our parkways are designed with a planting space between the roadway and sidewalk, so that edgestones are not necessary except at street intersections. Along roads with level grades, catch basins are installed about 200 ft. apart, the gutter being crowned 4 or 5 ins. half way between basins. The weight of castings, including both frame and grate, is about 500 lbs. The cost of the basin, not including excavation, has been by contract from $50.00 to $55.00.

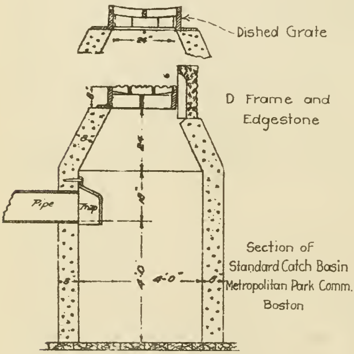

FIG. 13. MET. PARK COMM.

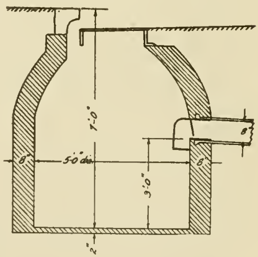

FIG. 15. FITCHBURG, MASS.

PHILIP W. TAYLOR. — The subject of catch-basin cleaning is one on which more and more study must be made. The conditions of labor, streets and dumping places offer new fields for study as time goes by. At the present price of labor and the increased demand for labor at far pleasanter occupations than cleaning catch basins, it is a question how much longer cities will be able to maintain efficiently their catch basins. The item of maintenance is increasing rapidly in most cities, and when the figures for this year are published there will be noted a marked increase in many cases provided the basins have been as thoroughly cleaned as in other years.

A very serious problem is the question of dumping. Very few cities have made any provision for dumping places, and consequently a large proportion of the cost of cleaning basins is due to long hauls. It seems to me that it is imperative that city officials should call the attention of the city governments to the need of providing proper dumping places. It is not necessary that the lots used for dumping be bought outright, but they may be leased for a period of years.

I desire to present to the Society to-night a few views showing the Otterson Auto Eductor for cleaning catch basins.

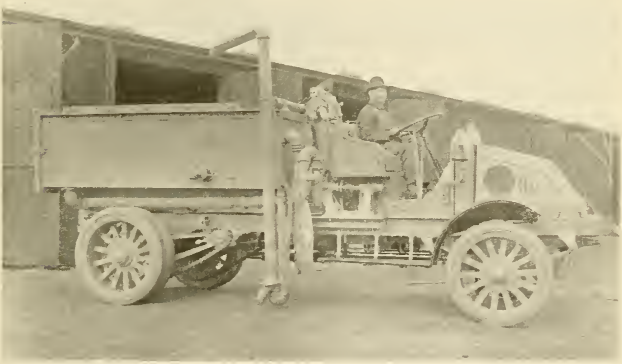

FIG. 14.

This machine is the invention of Mr. George W. Otterson, of Seattle, Wash., and has been used successfully in the West, and seems to be cleaning the basins very easily and economically.

The Auto Eductor (Fig. 14) consists of a centrifugal pump, sand eductor, dump body and necessary pipes and fittings, all mounted on a Kelly Springfield motor truck. The centrifugal pump is driven from the main engine shaft by a silent chain. The dump body is a steel box about 9 ft. long, 6 ft. wide and 3 ft. deep. It is divided into two chambers, one for the settling of the solids and the other to serve as a supply chamber for the

pump. The settling chamber is subdivided by vertical steel baffle plates which are the same depth as the dump body and about a foot less in width. These are staggered so that the water and pumped material must flow from side to side as it advances to the back of the machine. These baffles are hung on horizontal pipes at the top of the body and are free to swing so that when the load is being dumped and the body is in an inclined position the material may slide under them. At the back of the settling chamber there is a steel plate screen through which the water passes into the supply chamber.

The eductor is a patented device and consists of an orifice and throat as in the sand ejectors. This is made up of manganese steel on account of the severe wear to which it is subjected. The mouthpiece is made so as to be easily removed and renewed if necessary.

The operation of cleaning a basin is as follows: The truck is first driven to a hydrant and about 400 gals. of water taken on. The truck is then driven to the catch basin, the cover lifted and the pipe and eductor on the side is let down into the basin. The piping is so arranged that any basin located within six feet of the curb line may be cleaned. The suction valve in the supply chamber is then opened, allowing the water to flow into the pump by gravity. The pump is then thrown in by levers at the driver's seat, and the water flows through the hose down into the return bend in the basin, then up through the eductor into the settling chamber. A supply of water is taken from the pump discharge pipe into a small hose which terminates in a piece of ordinary wrought-iron pipe on the end of which there is a reducer which serves as a nozzle. By manipulating this pipe, which we may call an agitator, it is possible to soften the material and cause it to sluice toward the eductor inlet.

The material is sucked into the eductor and lifted into the settling chamber. It then flows from side to side, passing the baffles at alternate ends, and deposits the heavy material. It then flows through the screen into the supply chamber, thence to the pump and is ready for another cycle. In this way it is possible to use the original supply of water over and over until it is displaced by the heavy cleanings. After the basin is cleaned

the supply of water is shut off, the pump is stopped and the pipe lifted out of the basin by means of a crank and pulley on the side of the body.

After the settling chamber is full, which may be from two or more basins, the truck is driven to the dump and dumped by means of the hydraulic dump device which is driven by the engine.

The work may be done by an operator and one helper, but probably more efficiently with two helpers. It is unnecessary for any one to get into the basin. Material that is too large to pass through the eductor may be taken out with hook rakes from on top.

One very important feature of the machine is the possibility of cleaning the basins without making any litter on the street or creating a nuisance.

It is very necessary to the successful operation of this machine that the dump be controlled by the city. Owing to the weight of the truck when loaded (about nine tons) and the liquid condition of the material, it would probably be necessary to lay planks on the surface of the dumps.

In order to show the possibilities of this machine, I find in a report made to the Commissioner of Public Utilities of the City of Portland, Ore., that in a test of four and one-half hours' duration 84 basins were cleaned at an average cost of about nine cents per basin. In an actual day's work of eight hours the machine cleaned 137 basins. An interesting feature of the test above is that the total amount of material actually removed from the 84 basins was only 13 cu. yds., so that the cost averaged about sixty cents per yard, but it must be remembered that a large share of the time was spent in going from basin to basin and lowering the machine, so that the cost per cubic yard is high. In connection with this data it should be stated that in the West the large curb openings are absent and all of the water passes through the grate openings, therefore the material is much easier to handle than in the East, where almost anything in size up to a football may be found. It would seem as if it would be possible in the West to keep the basins in a much better sanitary condition than is possible in the East, for they may be

cleaned several times a year and not allowed to get dry, as often occurs in this part of the country.

Another use to which the eductor as described above can be put is a permanent installation in a grit chamber or large catch basin. By proper connections with city water mains, it is possible to clean these chambers simply by operating a valve and making the water lift the material to the truck. In Seattle several of these eductors are being used in specially designed grit chambers, and in one case the material is lifted over sixty feet in height by the water.

GORDON H. FERNALD.* — Fitchburg has about 1 000 catch basins of various sizes and shapes, but during the last four years we have adopted as standard, one which is 5 ft. in diameter and 7 ft. deep below the top of the curb (Fig. 15). The outlet or lead, usually 8-in. tile pipe, is three feet above the bottom of the basin, which gives a storage capacity of about $2\frac{1}{4}$ cu. yds. Unless the lead goes into a strictly storm sewer we use a cast-iron trap consisting of a flap valve to prevent odors coming from the sewer and a hood to prevent sticks or other obstructions from getting under the flap valve and holding it open.

These catch basins have a 2-in. brick bottom laid in dry cement and sand, with 8-in. brick walls, the top half of the walls being plastered on the outside to prevent frost action on the brick work.

The center of the basin is one foot out from the curb line and the basin is covered with a cast-iron frame and grate set in the gutter in addition to the gulley inlet. This grate is 24 ins. square and together with the frame weighs about 600 lbs.

Relative to the grate itself we have three different types· a solid cover, which we are gradually doing away with; a plain slotted grate, and a ribbed or rough surface grate which has been developed during the past two years and is very satisfactory.

On account of our many hills (some of which are very steep) it is necessary to bank our grates or else build a dam on the lower side in order to conduct the water into the basin. This is not an ideal way, therefore the ribbed or rough surface grate was

* Asst. Engineer, Sewage Disposal Comm., Fitchburg, Mass.

designed. This grate has the bars running diagonally with the sides or gutter and the back edge of each bar $\frac{1}{4}$ in. lower than the front edge of the grate. This arrangement makes a saw-tooth surface that slows down the velocity of the water reaching it and diverts it partially towards the gulley opening and partially down through the grate.

This grate clogs with papers, leaves, sticks, etc., as do all other grates, but even though clogged in most cases still diverts the water towards the gulley opening.

The cost of constructing a standard catch basin in 1913 was $75.97, this being an average of 20 basins built that year, and divided as follows:

Labor,	40%,	Mason and foreman, 34 cents. Common labor, 25 cents.
Castings,	19%,	$1.85 per 100 lbs.
Brick,	15%,	$9.50 per 1 000 delivered.
Cement,	8%,	$1.74 bbl.
Miscel. material,	8%,	Gulley stones: straight, $5.00 each; curved, $6.00 each. Traps, $5.00 each.
Overhead,	7%.	
Pipe leads,	3%.	

We spend annually between $3 000 and $4 000 in cleaning catch basins, making three complete rounds of the city and cleaning certain basins more often as needed. Some basins need not be cleaned more than once in two years, while others need attention five to eight times each year, depending on the rains.

On a complete round, our cleaning is carried on by one foreman, seven laborers and three double teams. The foreman determines which basins are to be cleaned and keeps the cost record of the work. Six of the laborers work in pairs, taking daily turns in going into the basins. The other laborer acts as loader together with the teamsters.

On reaching a basin to be cleaned, the top man bails out the water if any (a basin is not cleaned if it has 18 ins. of water in it) and then with a post-hole spoon takes out enough material so the bottom man can enter. The bottom man shovels the

material out of the basin and the top man piles it in the street for the teams to pick up.

FITCHBURG SEWER DEPARTMENT.

MAINTENANCE.

________________ FOREMAN.   ________________ 19____ DATE.

Catch Basin.	Loads.	Labor.				Dump.
		Time.	Bottom.	Top	Team and Loader.	

FIG. 16. TIME SHEET.

A time sheet (Fig. 16) made up to analyze the cost of catch-basin cleaning was developed in 1915 which shows some interesting cost figures. In the column " Catch Basin " is entered the location of the basin cleaned, in the " Loads " column the number of loads, time taken in cleaning in the " Time " column. The number of the bottom man goes in the column " Bottom," as does the number of the top man in the column " Top." The number of the team and loader are entered in their column, and the location of the dump under " Dump."

The distance of the basin from the dump is scaled from a map of the city to determine the length of haul.

The short haul shown in accompanying table for 1915 is probably accounted for by a severe storm on August 4, which caused several washouts, allowing us to take advantage of very short hauls by filling these holes.

The teams, being timed carefully during May and June, showed them to be on the road 45 per cent. of the total time. This apparently shows that some faster mode of transportation would reduce the cost of this item in the future, especially as,

TABLE 4.

COST OF CLEANING CATCH BASINS, FITCHBURG, MASS., 1915.

Month.	Catch Basins Cleaned.	Cu. Yds. Cleaned.	Av. Cu. Yds. per C. B.	Cost.			Total Haul One Way. Ft.	Av. Haul per Cu. Yd. One Way. Ft.	Av. Costs per Cu. Yd.			Total Av. Cost per Cu. Yd.
				Exc.	Load.	Team.			Exc.	Load.	Team.	
March	20	43	2.15	$33.34	*	$32.14	31 250	725	0.775	....	0.747	$1.52
April	133	318	2.39	168.06	$35.87	187.05	575 125	1 809	0.528	0.113	0.588	1.23
May	205	462	2.25	236.56	57.84	264.12	670 800	1 452	0.512	0.125	0.572	1.21
June	15	25	1.67	17.07	*	19.05	74 800	2 992	0.683	....	0.762	1.45
July	331	618	1.87	305.00	58.84	295.58	958 075	1 550	0.493	0.095	0.478	1.07
Aug.	290	715	2.47	326.80	59.35	357.89	961 400	1 345	0.457	0.083	0.500	1.04
Sept.	222	588	2.65	261.61	48.83	195.04	832 900	1 417	0.445	0.082	0.332	0.86
Oct.	32	59	1.84	24.13	*	26.50	43 150	731	0.409	....	0.449	0.86
Nov.	31	46	1.48	22.68	*	24.80	120 000	2 609	0.493	....	0.539	1.03
Totals and av.	1 279	2 874	2.25	$1 395.25	$260.73	$1 402.17	4 267 500	1 485	0.485	0.090	0.488	$1.06

Foreman's time divided proportionally into cost of exc., load and team.

* No regular loader, foreman and teamster loading.
Aver. cost shows exc. 45.6%, load 8.5%, team 45.9%.
Movement of teams for May and June shows them on the road 45% of time.
Labor, 28 cents per hour; teams, 62½ cents per hour.

owing to the normal growth of the city, longer hauls will be required to reach available dumps.

A " load " is a single load of catch-basin material. This is very indefinite, as they vary considerably, depending on the amount of water, or tin cans and rubbish, as well as the nature of haul, whether uphill, downhill, good roads or bad. An average of many measurements taken at various times shows in our case that a load is a cubic yard.

We feel that in addition to the detailed information gained by this method of cost keeping, the men and drivers are more careful to keep busy, knowing that their work is kept track of.

Henry A. Varney.* — The standard basin used in Brookline is the same type as that used in Cambridge. About thirty

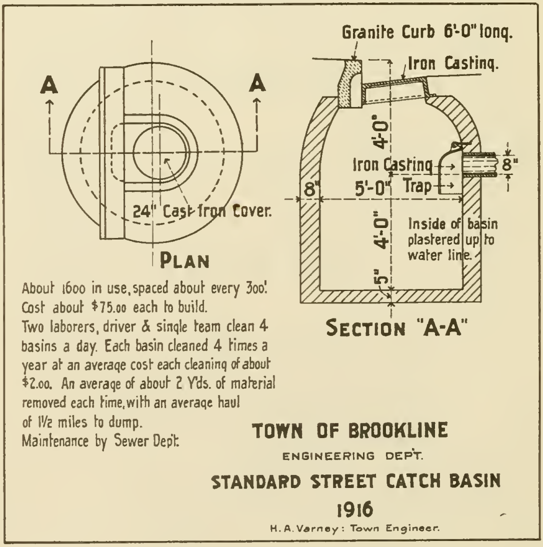

Fig. 17.

* Town Engineer, Brookline, Mass.

years ago the basins were built with a big granite top. The objection to this was that the opening came in the sidewalk and the cleaning was disagreeable for passersby. The present type of basin seems to be very satisfactory. In some cases we use a grating instead of a solid cover. The data given in Fig. 17 show all the obtainable information. I would say that we have used the double inlets to a certain extent in Brookline, but we usually put a basin at each end of the curb. It is rather expensive but it seems to be the best way.

Mr. Wm. A. Brown.* — In any community where a sewerage system is installed, there existed primarily the dual necessity of disposal of wastes and of surface or rain water. A sewerage system representing a big outlay must for utility and also for economy of maintenance be protected, and for this reason ordinances are usually enacted for the regulation of waste disposal, and catch basins are constructed for the reception of surface water.

A direct run into the sewer proper for surface water is always objectionable, for the very evident reason that material of various kinds, such as is always present in greater or lesser degree in the gutter, will be washed into the sewer, making a condition which will eventually result in the clogging of the system.

This is avoided by the construction of catch basins provided with a chamber for the sediment and supplied with a trap which prevents the access of rubbish to the sewer.

Fig. 18 illustrates the type of basin constructed in Providence. This basin is provided with a frame and cover designed in the city engineer's department, the cover being reinforced with ribs giving a light but serviceable construction and known as the "Providence Pattern."

At this date, there are in Providence about 5 700 catch basins and over 2 000 extra inlets.

One type of extra inlet, suitable for low points in the pavement, consists of a rectangular grating which is provided with a small sand catcher. These are used in car tracks and elsewhere

* Assistant Engineer, Highway Dept., Providence, R. I.

and are satisfactory, being supplied with an 8-in. pipe running to the nearest basin.

In some cases a "spider basin" is built, consisting of a catch basin in the street with extra inlets connecting therewith in several directions. This type of basin is considered generally unsatisfactory for obvious reasons.

The cleaning of the catch basins in Providence is done en-

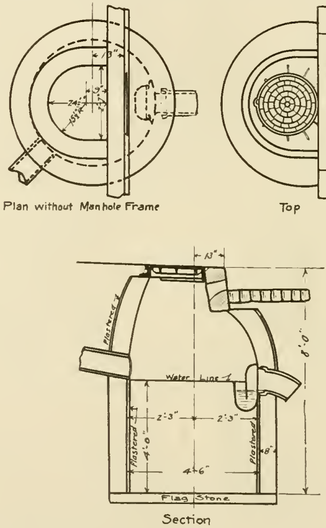

FIG. 18. STANDARD CATCH-BASIN, PROVIDENCE, R. I.

tirely by hand, a process which is satisfactory in its efficiency and also economical. On account of physical difficulties due to the fact that the so-called "East-Side" of Providence is built on a steep hill, the cleaning of basins in this section is more expensive, as a full load of material removed cannot be carried. As the cost of this work is kept in connection with other department work, it is not practicable to give a comprehensive statement of the cost, but it has been estimated that for day

work it costs $1.15 per cu. yd. and for night work $1.58 per cu. yd. for removal of material from basin, and this is estimated for an average haul of one and one-half miles.

Table 5, taken from the report of the "Department of Public Works" of Providence, 1915, page 33, shows the work performed by the Sewer Maintenance Department, cleaning basins for the fiscal year ending September 30.

TABLE 5.

WORK PERFORMED BY SEWER MAINTENANCE DEPT. OF PROVIDENCE, R. I. CLEANING CATCH BASINS FOR YEAR ENDING SEPTEMBER 30, 1915.

Month.	Number of Times Catch Basins Examined.	Number of Basins Cleaned.	Deposit Removed. Cu. Yds.
Oct., 1914	Once	1 106	1 669.10
Nov.	"	672	806.63
Dec.	"	175	247.92
Jan., 1915	"	159	341.78
Feb.	"	431	987.00
Mar.	"	1 275	2 217.21
Apr.	"	829	911.03
May	"	978	1 440.87
June	"	1 020	1 665.48
July	"	744	957.85
Aug.	"	715	1 825.00
Sept.	Twice	1 019	1 525.00
Total	13	9 123	14 594.87

1.6 cu. yds. deposit per basin cleaned.

The matter of the location of basins in streets is important, and I recommend it for serious attention. In my own observation, in many cities the location of basins seems to be at fault. Frequently the basins are so located as to bring the surface water during precipitation directly in the path of pedestrians, causing no little annoyance. A proper coöperation between the sewer engineers and the highway engineers would have remedied this fault, for the basins would have then been located with regard to this important feature of keeping the crossings dry.

This present season in this city witnessed an interesting change in the locations of several basins which had done excellent service for decades in their old locations but which, owing

to structural changes in a certain important street, were rendered practically worthless.

This was brought about by the rebuilding of Benefit Street with a permanent smooth pavement on a concrete base, to supersede the old macadam and cobble-gutter type of construction. Benefit Street being on a side hill and having steep cross streets presented a problem in changing from a macadam to a smooth pavement, especially at the intersecting streets on the low side. In several cases it was found possible to pave the street only by turning the surface water across the whole width of the roadway, and by so doing the basins on the high side had to be discarded and extra provision for the added flow of water made on the low side.

I wish to acknowledge assistance in preparing this brief discussion from Mr. John E. Bowen, assistant engineer, City Engineering Department, and from Mr. Colver L. Saunders, superintendent of Sewer Maintenance Department, of Providence.

Mr. Edwin H. Rogers.* — The city of Newton, Mass., comprises an area of 18 square miles, has 145 miles of accepted streets and 79 miles of private ways. To January 1, 1916, its surface drainage system consisted of 60 miles of stone, brick and concrete conduits and vitrified pipe drains, with 2 637 catch basins, or an average of one catch basin for each 120 lin. ft. of drain.

In constructing new streets for acceptance or when installing a drainage system in old streets, it is customary to place catch basins on each side at a maximum distance of 300 ft. apart on continuous grades, at such other points as changes in grade may require, and near each tangent point of the curves forming the street corners.

For a number of years past, the catch basins have been built mostly of brick, circular in section, with an inside diameter of about 4 ft., and about 6 ft. in depth. The brick side walls are laid in cement mortar, are 4 ins. in thickness for the cylindrical portion, which is from 3 ft. to 4 ft. in height, and the arch

* City Engineer, Newton, Mass.

supporting the gratings is 8 ins. in thickness. The bottom of the basins is paved with brick laid flat, without cement, 2 ins. in thickness, the joints being filled with dry sand. The basins are not provided with traps, and the outlets are usually 8-in. pipes leading directly to the drains.

The topography of the city is such that a majority of the drains have sufficient pitch to keep themselves clean of such materials as may wash into them from the basins. The outlets are usually placed so as to provide from 1½ ft. to 2 ft. of cover over the outlet pipe whenever the grade of the drain to which they are connected will permit.

The covers on a large majority of the basins are Concord gratings with a convex top. This type of grating is inexpensive and has proved fairly satisfactory on our residential streets, but these gratings are now considered unsuitable on thoroughfares having a traffic of other than light vehicles.

Special apparatus is not used for cleaning the catch basins, the street washings being removed from the basins by the use of spoon shovels, deposited on the surface of the street, and then loaded into carts and carried away to the most convenient dump. The work is done by the street department by day labor, the average amount removed per basin per year being 1.9 cu. yds., at a cost in 1915 of $1.90 per basin, or $1.00 per cu. yd. Dumps are numerous, and the length of haul seldom exceeds one mile. The basins are not cleaned at regular or specified times. They are all thoroughly cleaned in the fall of the year and at such other times as may be necessary.

Complaints of catch basins as a source of mosquitoes are infrequent, and the reason for this is attributed to the use of oil on the majority of the streets, which tends to wash into the basins and prevent the breeding of these pests.

MR. W. L. VENNARD.* — The standard catch basin of the city of Lynn (Fig. 19) is built primarily to catch gravel and other sediment carried by storm water in the gutters. Most of the basins of Lynn empty into the combined sewerage system. Some are drained into culverts carrying brook waters. They

* City Engineer, Lynn, Mass.

work efficiently when built to the standard pattern and are useful to keep gravel from entering our sewers.

The basins are cleaned by hand, which is to say, a man goes into the basin, shovels the gravel into buckets and it is raised

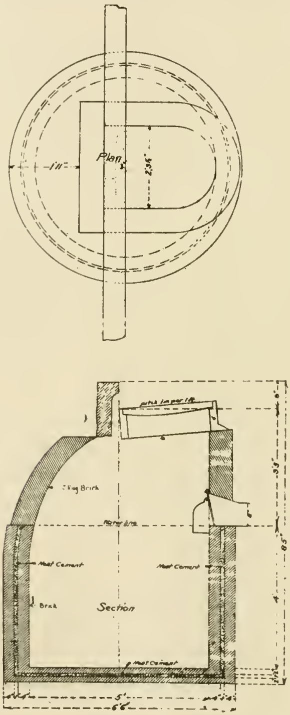

FIG. 19. LYNN PATTERN.

by hand and dumped into a cart which hauls it to a dump. The opening for cleaning the modern basin is through the throat of the D-grate in the gutter, there being no opening in the sidewalk. It will be noted that the openings in the D-grate are

supplemented by a throat cut in the curbstone, and I wish to remark that the basins, as sometimes built without throats, do not take the water efficiently. The grate, at the beginning of a rainstorm, becomes covered with leaves and paper or other débris and the water passes over, while those that have the throat permit the water to enter through it and the swirl of water entering generally tends to keep the grate clearer from débris than when there is no throat.

The cost of cleaning basins in 1915 was as follows:

Labor	$3 619.86
Teams	663.34

This, together with the cost of salt and a few incidentals, brings the total to $4 359.85. The single teams are hired from the highway department by the drainage department, $0.17 per hour being charged for same and $0.36 for double teams per hour.

Total number of basins cleaned in 1915	1 442
Average cost of basin cleaned in 1915	$3.02

The basins are built 8 ft. deep and have a trap at the outlet 4 ft. above the bottom, which causes a water seal in tight basins, preventing odors from arising from the sewer.

The length of haul is estimated to be one mile.

Other costs of cleaning are given below, in Table 6.

TABLE 6.

Cost of Cleaning Catch Basins in Lynn, Mass.

Year.	Number of Catch Basins Cleaned.	Total Cost of Cleaning Basins.	Average Cost of Cleaning per Basin.
1899	1 138	$2 537.74	$2.23
1900	731	1 834.81	2.51
1901	1 110	2 286.60	2.06
1902	671	1 570.14	2.34
1903	835	1 928.85	2.31
1904	891	1 844.37	2.07
1905	956	1 921.56	2.01
1906	1 047	2 355.75	2.25
1907	1 004	2 148.56	2.14
1908	1 153	2 279.54	1.97
1909	988	1 729.71	1.75
1910	....	......	....
1911	....	2 831.00	....
1912	1 417	2 806.03	1.98
1913	1 742	3 715.20	2.13
1914	....	......	....
1915	1 442	4 359.85	3.02

Mr. Fred R. Charnock.* — It is our custom to build catch basins for the reason that the gradient of a great many of our surface drains is so flat that it is necessary to retain as much sediment in the catch basins as possible. If we had grades sufficiently steep to keep the pipes clear, I should probably omit sand catchers in many locations.

Catch basins are cleaned by manual labor. We have no special apparatus for this purpose, for, the bottom of the basins being only six to seven feet below the surface, we have no particular trouble in keeping the basins clean in this manner.

The cost of cleaning at the present time is about 75 cents per cu. yd.

The average haul of the dumps is about one-half mile.

In the year 1913, which is the latest time on which I have the data available, there was 1 058 cu. yds. removed from the basins, and the cost was $738.69 for labor and teaming.

Mr. Walter E. Noble.† — The standard catch basin used in Fall River is shown in Fig. 20. A few catch basins in connection with special work have been built of concrete and a few of the brick ones have had reinforced concrete cover stones, but granite in large blocks is plentiful here, and that continues in general use.

We have practically no direct openings from the gutter to the sewer, and, while I recognize the force of some of the arguments advanced in favor of such openings under some conditions, I should be reluctant to recommend their adoption here under the existing conditions.

There are a good many steep streets in Fall River, some with slopes of 15 per cent., and every heavy rain washed down to the basins a large amount of dirt and, even with them, a considerable quantity collects in the outfall sewers and about their outlets.

Catch basins are cleaned generally by three men, one in the basin filling pails and the others on the surface hoisting out by hand rope and dumping. The material is removed in carts

* City Engineer, Medford, Mass.

† Assistant City Engineer, Fall River, Mass.

with metal bodies to the most convenient place of disposal, which is generally a house lot below grade.

The annual report of the Street Department for the year 1915 states that there were 3 091 cleanings of catch basins, which would be an average of 2.87 times for each of the entire

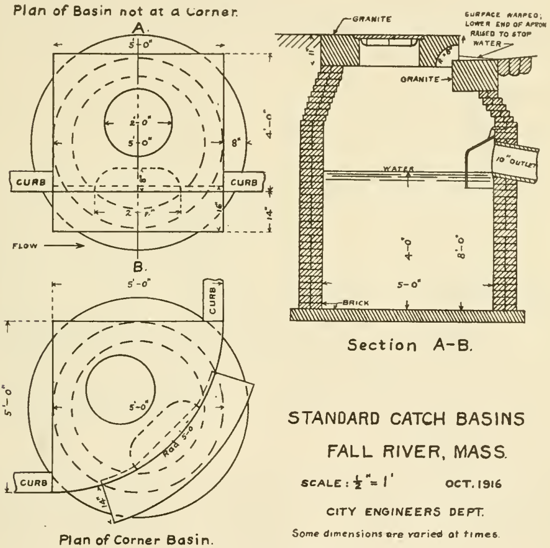

FIG. 20. FALL RIVER, MASS.

number in use, although actually some basins were cleaned a great many more times and some not more than once, if at all. The average cost for each cleaning is given as $4.09.

MR. JOHN H. GREGORY.* — I wish to call attention to an article on "Hydraulic Ejectors for Grit Removal Merit Trial in Sewer Maintenance," published in the *Engineering Record* of January 29, 1916. If I were to prepare a discussion I could not

* Of Hering & Gregory, Consulting Engineers, New York.

express my views better than in this article. The two photographs shown in the article are, so far as I know, the only ones in this country of the Frankfort wagon used for cleaning catch basins.

Mr. Frank A. Marston.* — Catch basins have been in use for many years, and for some time were considered a most necessary part of a sewerage system receiving storm water. Street detritus was washed into the sewers in times of storms and collected in sections where the velocity was low, forming deposits which were expensive to remove. The practice of building catch basins to intercept this material is still followed in many of the older American cities, and in some places this practice has become a matter of custom rather than a need.

Many of these basins are constructed with traps or water seals to prevent air from the sewers being discharged through the inlets into the streets. There appears to be some question as to whether this practice is justified. The value of catch basins or inlets which are untrapped, as a means for ventilation of the sewer, has been recognized for many years.

In the report of Samuel M. Gray on the proposed plan for a sewerage system in the city of Providence, presented in 1884, is the statement:

"As the inlets to the catch basins are likely to be kept free from snow, such of them as can be left untrapped without causing offense may be left in that condition to serve for ventilation when the openings in the center of the street are covered with snow."

There is a growing tendency to omit traps from inlets, as shown by the latest designs prepared by the cities of St. Louis, Pittsburgh and others.

Several investigators have pointed out that catch basins may become breeding places for mosquitoes unless means are taken to prevent. This difficulty is removed where inlets of proper type can be constructed in place of structures holding water.

* Designing Engineer, Metcalf & Eddy, Consulting Engineers, Boston.

Catch basins have been constructed to suit particular needs and the ideas of various designers. A number of typical designs which have been adopted as standards for various cities are shown in the accompanying figures.

Fig. 21 shows the standard catch basin used for many years in the city of Columbus, Ohio. The interior diameter of the basin is about 3 ft. 6 ins., and the depth of water below the invert

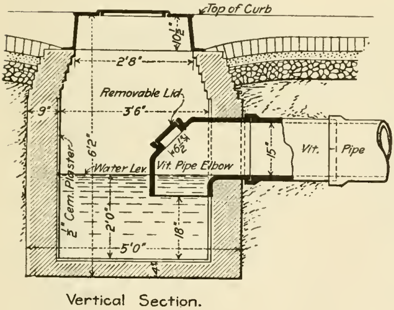

FIG. 21. COLUMBUS, OHIO.

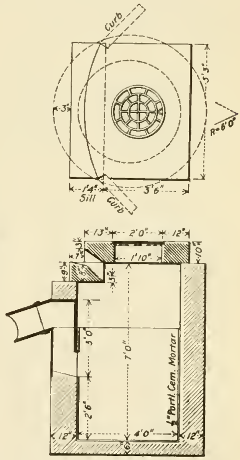

FIG. 22. NEWARK, N. J.

of the trap is 2 ft. There is one chief objection to this design; that is, the danger of breaking the trap, which is of vitrified clay, either while the work of cleaning the basin is in progress or by freezing in the winter. This objection could be partially obviated by the substitution of a cast-iron elbow in place of the vitrified pipe elbow.

The standard catch basin used at Newark, N. J., is shown in Fig. 22. This is of a different type, in which the trap is constructed as a part of the wall of the basin. The interior of the basin is 4 ft. in diameter, and the depth of water below the invert of the outlet pipe is about 4 ft. In this form there is no

grating, all the water entering through the opening in the side of the curb.

Fig. 23 shows the type of catch basin used as a standard design in the borough of the Bronx, New York. This basin is constructed of reinforced concrete or brick masonry about 3 ft. 6 ins. by 4 ft. 11 ins. in plan, with a depth of water below the invert of the outlet pipe of 3 ft. 4 ins. The water enters the basin through an opening in the side of the curb. Six standard modifications of this design have been provided for varying condi-

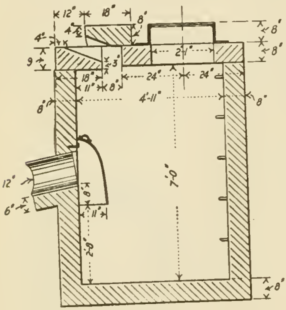

FIG. 23.

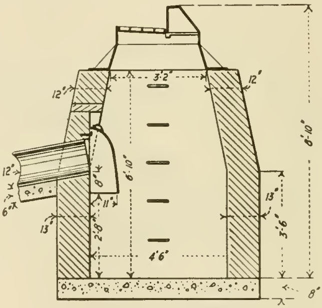

FIG. 24.

BOROUGH OF THE BRONX, NEW YORK.

tions and the use of other materials. Fig. 24 shows the type adopted for the circular brick catch basin, in which the water enters through an opening in the side of the curb as well as through a grating in the gutter.

The standard catch basin adopted by the borough of Manhattan, New York City, is of a similar design as shown in Fig. 25, this particular basin being intended for use on the corner at a street intersection. The interior of the basin is 4 ft. in diameter.

The standard catch basin adopted in Pittsburgh, Pa. (Fig. 26), is one of several published by the Department of Public Works of Pittsburgh in 1911. (See also *Eng. & Cont.*, July 17, 1912, p. 73.) The interior of the basin is rectangular in plan, 4 ft. 6 ins. by 3 ft. 6 ins., and the depth of water below the invert

of the outlet pipe is 20 ins. The water enters this basin through an opening in the side of the curb, there being no grating in the gutter.

The standard catch basin in the city of Boston, described by Mr. Dorr, has proven satisfactory in most respects and has

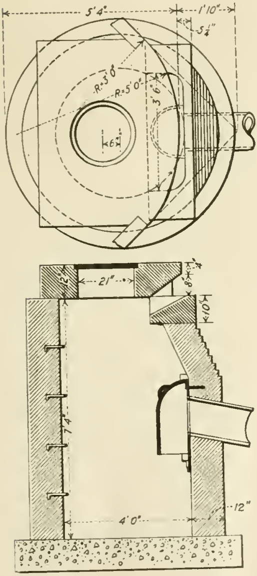

FIG. 25.
BOROUGH OF MANHATTAN, NEW YORK.

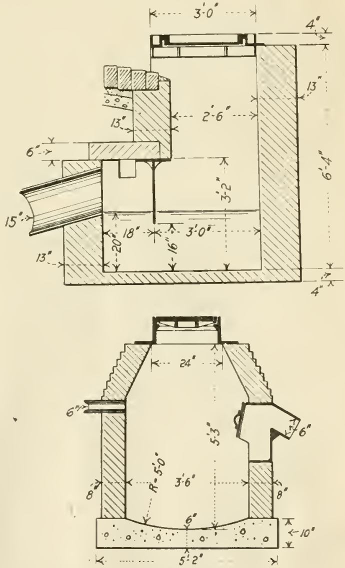

FIG. 26.
PITTSBURGH, PA. (upper)
SEATTLE, WASH. (lower)

been adopted for use in a number of other cities and towns. Both the form of trap and grating are noteworthy features and have many points to recommend them for use.

The catch basin used at Providence, described by Mr. Brown, is also of a satisfactory design. The basin is put out of service automatically when it becomes filled with sediment.

The particular feature of this design is the trap, which allows water to pass through until the sediment accumulates to the top of the trap, when the addition of more sediment causes the trap to become filled and the basin to become automatically blocked against the further discharge of sediment or water into the sewer. The shape of the trap also permits water standing above the sediment to be bailed into the trap by the " bottom man," and obviates the necessity of hoisting this water to the street surface.

The standard forms of brick catch basins in use at Indianapolis, Ind., and at Milwaukee, Wis., are shown in *Engineering and Contracting*, January 10, 1912, p. 42, Vol. 37. The Indianapolis basin is 4 ft. 6 ins. in diameter on the inside and has a depth of water of about 3 ft. The Milwaukee basin is about 4 ft. in diameter with a depth of water of a little over 3 ft.

The standard catch basin used in Seattle, Wash., has no direct inlet from the street, but is intended to serve two or more inlets connected by 6-in. pipe. The standard Seattle basin has an interior diameter of 3 ft. 6 ins. and a depth of water below the invert of the outlet pipe of 2 ft. 11 ins. A similar basin, 4 ft. x 2 ft., elliptical in plan, is also built. Both of these structures were described in *Engineering and Contracting*, Vol. 36, July 26, 1911, pp. 101 and 104. The curb inlet is provided with a cast-iron grate, but has no trap or any receptacle for grit.

The standard catch basin adopted for Portland, Ore., is an entirely different design from those previously described. It is shown in *Engineering and Contracting*, Vol. 37, January 10, 1912, p. 42. This is the structure referred to by Mr. Taylor in his description of the work done by the Otterson auto truck. The basin is rectangular in plan, 30 ins. long by $11\frac{3}{4}$ ins. wide, with a depth of water below the invert of the outlet pipe of about 3 ft. 11 ins. The outlet has no trap. The storm water flows through a heavy curved grating set in the gutter directly over the basin.

Fig. 27 shows the standard type of catch basin and inlet used in Springfield, Mass. The basin is somewhat different from the customary form, in that the sides are constructed on a straight batter from the floor up. No trap is used on either the basin or inlet. The cast-iron frame and cover are of a heavy

type. The cover or grate is 20 ins. in diameter and $4\frac{1}{2}$ ins. deep. There are 20 openings, each $1\frac{1}{8}$ ins. wide, with a maximum length of 5 ins. There are also openings in the side of the grate, allowing water to pass down between the edge of the grate and the rim of the frame, through the side of the grate into the basin. Blue prints from which this drawing was made were furnished by Frederick H. Clark, superintendent of streets and engineering, Springfield.

In recent years, the use of catch basins has been decreasing, and in its place inlets have been designed to furnish a direct

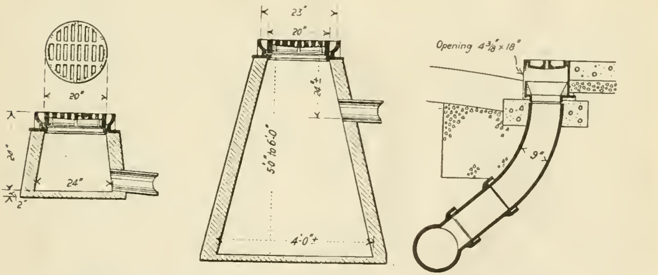

FIG. 27. SPRINGFIELD, MASS. PITTSBURGH, PA.

connection between the street and the sewer, either with or without a water-seal trap.

It is interesting to note that there are no catch basins in Rochester, N. Y. Mr. Edwin A. Fisher, consulting engineer to the city, states that while they have had some difficulties due to the deposit of grit in the older sewers, and have found it necessary to adopt special ordinances for cleaning, on the whole they have had very little trouble from the lack of catch basins. The sewers, as a general rule, have very good grades, and the outlets to the river have free discharge.

Messrs. Rudolph Hering and Samuel M. Gray, reporting to the city of Baltimore in 1896 on sewerage and drainage, advised as follows:

"We are also of the opinion that the inlets should not be

provided with catch basins to retain the silt or whatever may be washed into them."

Another statement, to be found in the report of the Metropolitan Sewerage Commission of New York for 1914, is as follows:

"Some sewerage systems are without catch basins, and their elimination as a general procedure is much to be desired."

Similarly, in the report of the Commissioners of Sewerage of Louisville, by J. B. F. Breed and Harrison P. Eddy, 1913, there is the following statement:

"Careful consideration was given to the desirability of building inlets rather than catch basins, as had been the city's custom for many years. It was felt, however, that in this climate it was unwise to provide pools of water in which mosquitoes could breed, as is the case where catch basins are built, and further that under existing conditions the catch basins for the retention of detritus were not necessary in most cases. It was also found that it was already the practice of the Board of Public Works to build inlets instead of catch basins. The inlets built have been untrapped, and the experience thus far indicates that this type of inlet has given satisfaction."

Other references of a similar nature including the above, are given in greater detail in "American Sewerage Practice," Vol. I, pp. 520 to 522. Additional opinions might be cited to show that the trend of practice at the present time is towards the elimination of catch basins as far as practicable. There are locations, of course, where the conditions are such as to make it advisable to install catch basins to collect the sediment and prevent its being discharged into low-level sewers constructed on flat grades. In a modern sewerage system, however, where self-cleansing velocities in the sewers are maintained, and where the surfaces of the streets are paved and are kept in a fairly clean condition, it is believed that inlets will be found more satisfactory than catch basins. The cost of an inlet is materially less than that of a catch basin, and consequently it will be possible to provide better drainage for the same cost than as if catch basins were used throughout.

A number of standard types of inlets are shown in the accompanying figures.

The standards adopted by the borough of the Bronx, New York City, are shown in Fig. 28. This figure shows five different types of inlets, one of which is trapped. With inlets of this type there is not so much tendency on the part of the street cleaners to push sweepings into the opening. In dry weather a considerable quantity of such sweepings may be pushed through the opening of the ordinary basin without the condition of the basin

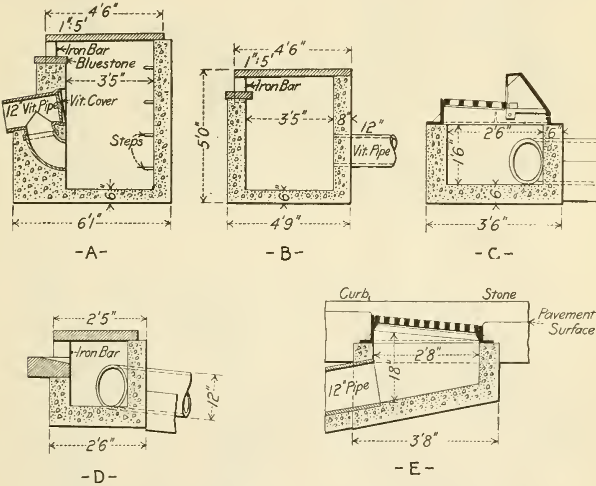

FIG. 28. BOROUGH OF THE BRONX, NEW YORK.

becoming apparent, but with the shallow inlet which has but little capacity for sediment, such a practice would soon be noticed and, if continued, the inlet would become clogged before a very material quantity of refuse had been so deposited.

The standard forms of inlet adopted for Philadelphia are shown in Fig. 29, one of which has an opening in the side of the curb and the other a grate in the gutter, through which the water is discharged into the sewer. Both of these inlets are trapped to prevent odors from the sewers reaching the street surface.

A design of inlet used by Metcalf & Eddy is shown in Fig. 30. The cost of this inlet is low, the construction simple and the area of grate opening large. The design shown provides for an

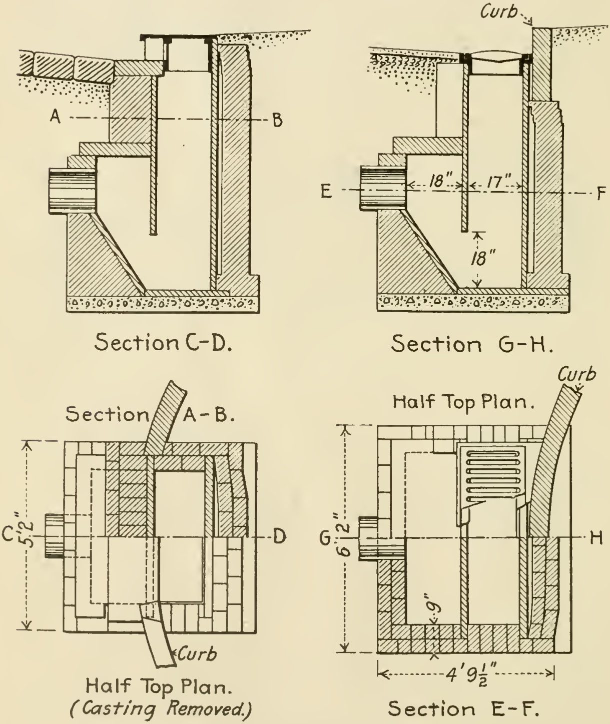

FIG. 29. PHILADELPHIA, PA.

18-in. diameter grate. This can readily be modified as the conditions require, using either a larger or smaller grate for the particular purpose.

In 1913 and 1915 a number of such inlets were constructed

at Hopedale, Mass. The cost in 1915 of the inlets complete, in earth excavation (excluding rock excavation), including pipe and cast-iron grating, was about $46 for a 24-in. inlet and $33 for an 18-in. inlet. This is a considerable saving over the cost of catch basins, which would probably have amounted to $75 to $100 each. The superintendent of streets of Hopedale has had no trouble with these inlets, except when children put sticks down through the grating. These form a dam over the outlet,

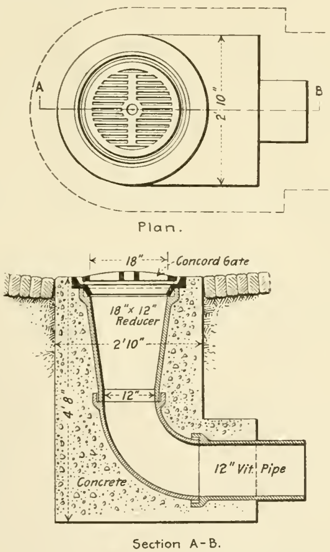

FIG. 30. METCALF & EDDY INLET.

and in time dirt accumulates back of them and the inlet fills up. Where this occurs, the obstruction can be easily removed. Inlets of a similar type have been in use on a side hill street for twenty-five years, with a catch basin at the foot of the hill. This basin is cleaned out periodically, but none of the inlets along the slope of the hill have required cleaning.

At Baltimore, following the advice of the consulting engineers, inlets were used in the improved sewerage of the city. The inlet is without a sump or collector and the flow passes directly from the street to the sewer or drain. These inlets are described in *Engineering Record*, December 19, 1908, p. 700.

The standard form of inlet used at St. Louis was changed radically in 1915. Both the old form of inlet and the new inlet are described in *Engineering News*, September 30, 1915, Vol. 74, p. 652. The old form of inlet was very similar to that in use at Philadelphia. The new type of inlet allows the water to drop quickly from the gutter to the inlet, on account of the beveled edge given to the sill. This is of importance, especially on side hills, where there is a tendency for the water flowing in the gutter to rush past the inlet and surcharge inlets at the foot of the slope. It is intended to use the trapped type of inlet where the connection is to a sewer on a flat grade, and also where the inlets drain Telford streets on grades steep enough to allow the gravel to wash into the gutters. For all other locations the inlets without traps will be used.

The new designs for curb inlets at Pittsburgh, Pa., published in *Engineering News*, January 27, 1916, p. 156, are of interest. The connection from the street opening to the drain is 9-in. or 12-in. vitrified clay pipe, depending on the type used. A contract for street reconstruction awarded during 1915 included the construction of 313 of these inlets at a contract price, complete in place including concrete and cement filling, of $20 per inlet. The inlets are located about 40 ft. apart along the curb line, and discharge into a 12-in. pipe laid about 5 ft. under the surface of the street. The collecting drains discharge into special trapped manholes leading to the combined sewers. The manholes are trapped to prevent the escape of odors or steam in the combined sewer.

Cleaning Catch Basins.

Careful records are kept at Worcester, Mass., to show the cost of cleaning the catch basins. Some of these data, taken from the annual reports of the superintendent of sewers, are shown in Table 7. Each basin is cleaned by two men, one a

TABLE 7.

DATA REGARDING CLEANING OF CATCH BASINS AT WORCESTER, MASS.

(Taken from Annual Reports of Supt. of Sewers.)

Year Ending Nov. 30.	Total Number of Catch Basins in System.	Number of Cleanings during the Year.	Av. Amount of Material Removed per Cleaning.†	Av. Amount of Material Removed per Basin per Year.	Cost of Cleaning per Cu. Yd. Deposit Removed.*	Cost of Removing Material per Catch Basin per Year.*	Minimum Wage for Labor —8 Hours.
1905	2 748	....	...	7.5	$0.41	....	$1.85
1906	2 818	4 652	3.93	6.5	0.57	$3.69	1.85
1907	2 902	4 804	3.04	5.1	0.81	2.48	1.85
1908	3 014	5 053	2.72	4.6	0.81	2.20	1.85
1909	3 138	5 142	2.43	4.0	0.80	1.94	1.85
1910	3 251	6 094	2.45	4.9	0.74‡	1.82	1.85
1911	3 322	7 035	2.35	5.1	0.69	1.65	1.85
1912	3 413	6 783	2.56	5.1	0.83	2.13	2.00
1913	3 507	8 014	2.36	5.4	0.80	1.89	2.00
1914	3 563	5 522	2.65	4.1	0.82	2.18	2.00
1915	3 746	6 095	2.43	4.0	0.82	1.95	2.00

* Includes cost of teams, labor removing refuse from basins, all inspection and looking after clogged and frozen traps.

† Based on haul at rate of $1\frac{3}{8}$ cu. yd. per load to 1909 inclusive, after that date, $1\frac{1}{2}$ cu. yd. per load.

‡ Began using Watson dumping wagons in place of tip carts. Length of haul gradually increasing.

" bottom " man, who shovels the grit from the basin to the surface of the street, and the other who trims off the piles on the street surface and helps to load them into the cart. Several such gangs are sent to one district, under the supervision of a foreman. In this manner the work is done efficiently and at a reasonable expense.

In Table 7 it will be noted that the number of catch basins in use in the system has increased from year to year, approximately as the growth of the city and the sewerage system have increased. The basins are cleaned about twice per year on the average, some basins being cleaned only once a year, while others are cleaned more frequently, depending upon the location and the amount of sediment deposited in the basin. The average amount of material removed from each basin at each cleaning is in the vicinity of $2\frac{1}{2}$ to 3 cu. yds. The average cost to remove the deposit from the basins, for the years 1905 to 1915, inclusive, was 73c. per cu. yd. The cost for the years 1914 and 1915 was 82c. per cu. yd., this increase being due partly to an increased cost of labor and also to the increased length of haul required as the district becomes more thickly populated and the available dumping places near by become filled. From 1905 to 1911, inclusive, the minimum wage for labor for eight hours was $1.85. After that date the mimimum wage was $2. The " bottom man " was paid a higher rate than the minimum, amounting to $2.10 to $2.25 per eight-hour day. The cost of teams was $5 per day to 1914 and $5.50 in 1915, including the driver. Formerly the driver assisted in loading his cart, but now all teams are hired and it is impossible to get drivers to shovel.

The catch basins now constructed in Worcester vary in size according to the requirements, but for the most part they are elliptical in plan, constructed of brick masonry, with interior dimensions of 4 x 6 ft., a maximum depth of 7 ft. below the surface of the gutter, with a depth below the invert of the trap of about 4 ft. The top is finished with a cast-iron D frame containing a removable grating. As a general rule, the basins are built with a curb inlet. The average capacity of the basins below the trap is about 3 cu. yds. Various forms of traps have been

used, but that used most frequently is the so-called Coleman trap, very similar in design to the trap used in the standard catch basins at Providence. This trap has in general proved satisfactory, although some trouble is experienced due to freezing of the water seal, especially on drains. The trap is also somewhat more liable to clog than some other designs. This happens especially when the basin becomes filled with sediment so that it overflows into the trap.

Table 8 shows the cost at Worcester, Mass., for thawing and freeing catch-basin traps from 1911 to 1915, inclusive.

TABLE 8.

COST OF THAWING AND FREEING CATCH-BASIN TRAPS.

Year Ending Nov. 30.	Number of Basins in Service.	Cost of Thawing and Freeing Traps.	Cost of Thawing and Freeing Traps per Basin.
1909	3 138	$104	$0.03
1910	3 257	459	0.14
1911	3 322	694	0.21
1912	3 413	1 603	0.47
1913	3 507	1 189	0.33
1914	3 563	1 022	0.29
1915	3 746	833	0.22

TABLE 9.

SEWER CLEANING IN WORCESTER, MASS.

Year Ending Nov. 30.	Miles of Sewers in System.	Quantity Deposit Removed in Cu. Yds.	Total Cost of Cleaning including Flushing.	Cost of Cleaning Sewers per Cu. Yd. of Deposit Removed including Flushing.
1905	177	1 484	$5 754	$3.88
1906	180	972	6 391	6.54
1907	183	665	6 478	9.74
1908	188	909*	5 306	5.84
1909	192	825*	6 007	7.28
1910	199	580*	4 535	7.82
1911	205	635	4 533	7.14
1912	213	724	4 665	6.45
1913	222	860*	4 711	5.50
1914	229	470*	4 511	9.60

* Includes sediment removed from regulators.

The unit costs of thawing and freeing traps per year per basin in service varies from 21c. to 47c.

One of the strong arguments for constructing catch basins is that it is cheaper to clean the sediment from the catch basin than it is to remove it from the sewer. In this connection it is interest ng to compare the cost of sewer cleaning at Worcester, Mass., with the cost of cleaning catch basins for corresponding years. These data are shown in Table 9. The unit costs of cleaning sewers, based on the cubic yards of deposits removed for the years 1906 to 1914, inclusive, varied from $4.56 to $8.26 per cu. yd. of deposit removed, exclusive of the cost of flushing sewers; and with flushing included, the cost of cleaning per cubic yard of deposit removed varied from $5.50 to $9.74.

For comparison with the above, the cost of removing the deposit from catch basins as per Table 7 varied from $0.41 to $0.83 per cu. yd. It is evident that if material is allowed to enter the gutter openings with the certainty of being deposited at some point in the drainage system, it is more economical to remove the deposit from catch basins than from the sewers.

If, on the other hand, the catch basins collect material which would have been carried along in the drainage system without being deposited, the basins become a source of expense that is not justified. Under such circumstances the basins should be replaced by inlets.

From the figures given in Table 7 it is assumed that the annual cost of cleaning a catch basin is $2.00. In all probability, the catch basin could be replaced by an inlet for an expense not exceeding $50 to $75. The annual expenditure of $2.00, allowing interest at 4 per cent., represents an investment of $50. Thus in one to two years' time would be saved the cost of replacing the catch basin with a suitable inlet involving practically no further charges for cleaning. The character of the street surface or pavement and the method of street cleaning are two factors which strongly influence the question of the use of catch basins. Even where smooth, hard pavements such as wood block or asphalt are laid, and it would at first thought appear unnecessary to provide for catching grit, such provision is necessary at times because of the practice of sanding the pavements

on rainy days to make them less slippery. Sand, stone and brick dust and other solid materials fall from passing carts in appreciable quantities where traffic is heavy. Such material will be washed into the drains during sudden showers in spite of all care in street cleaning.

Where paved streets are cleaned by flushing, a large quantity of detritus will be washed into the drains. There may be some question as to whether it is more economical to remove such material from the catch basins and drains after street flushing, or to sweep the streets and gather the detritus up from the gutters. Street sweepers seem to have acquired a reputation for pushing sweepings into basins and inlets, so that either method of cleaning may result in detritus being discharged into the drains, either by design, accident or otherwise.

One factor which has tended to produce unsatisfactory results, as regards the construction and maintenance of catch basins in many cities and towns, is the lack of coöperation between the various departments having in charge the design, construction and maintenance of the basins. If all of this work could be under the general supervision of one official, much better conditions might prevail. In many cities there is no adequate inspection of the basins and no regularity or system of cleaning. Oftentimes such basins are worse than useless, as they become filled, create objectionable odors and permit a large quantity of material to be discharged into the sewers in time of storm.

In the opinion of the writer, the results of the discussion may be summarized as follows:

1. Where combined sewers or drains are laid on very flat grades, not providing self-cleaning velocities, catch basins are useful to catch detritus in order that it may be removed more economically than from the sewers or drains.

2. A considerable saving in the cost of cleaning catch basins can be effected by the use of a suitable motor-truck equipment.

3. Of the two examples of motor-truck apparatus described, that developed by Mr. Carpenter appears to meet the conditions in New England cities where the Otterson machine failed, although successful in the West.

4. Where self-cleansing velocities can be obtained in the

drainage system, from the surface connections through to the point of discharge, inlets without traps should be built in preference to catch basins, both for economy and better service.

It may be more economical to construct a single catch basin in the main drain at the head of a section laid on a very flat grade rather than to build catch basins for a large number of surface connections.

5. Oil should be applied to the water in catch basins, to prevent the breeding of mosquitoes.

6. Catch basins should be regularly inspected and should be cleaned after each severe storm if necessary.

7. Catch basins should be built only where necessary, because of special conditions, and not as a matter of custom, as appears to be the practice in some cities.

8. Unless catch basins are actually catching grit, which would otherwise be deposited in the sewer or drain, they should be replaced by inlets.

Figs. 21 to 30 inclusive were from the following sources:

Fig. 21. Catch basin, Columbus, Ohio.
From " American Sewerage Practice, Vol. I — Design of Sewers."
McGraw-Hill Book Company, Inc.

Fig. 22. Catch basin, Newark, N. J.
From " American Sewerage Practice, Vol. I — Design of Sewers."
McGraw-Hill Book Company, Inc.

Fig. 23. Concrete catch basin, borough of the Bronx, New York.
From book of standards published by the city.

Fig. 24. Brick catch basin, borough of the Bronx, New York.
From book of standards published by the city.

Fig. 25. Catch basin, borough of Manhattan, New York.
From " American Sewerage Practice, Vol. I — Design of Sewers."
McGraw-Hill Book Company, Inc.

Fig. 26. Catch basin, Pittsburgh, Pa.
From book of standards published by the city.

Fig. 27. Inlet and catch basin, Springfield, Mass.

Fig. 28. Inlets, borough of the Bronx, New York.
From " American Sewerage Practice, Vol. I — Design of Sewers."
McGraw-Hill Book Company, Inc.

Fig. 29. Inlets, Philadelphia, Pa.
From " American Sewerage Practice, Vol. I — Design of Sewers."
McGraw-Hill Book Company, Inc.

Fig. 30. Inlet, Metcalf & Eddy.
From " American Sewerage Practice, Vol. I — Design of Sewers."
McGraw-Hill Book Company, Inc.

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PAPERS AND DISCUSSIONS

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FLOOD CONTROL IN THE MIAMI VALLEY.

By Arthur E. Morgan.*

The map of Ohio shows the Miami River in the southwest part of the state, emptying into the Ohio River near Cincinnati, and as far upstream as Dayton, and also the Mad River beyond, extending in a direct line from southwest to the northeast. Practically all important tributaries enter from the west of this line, the smaller ones having very steep slopes, with the result that during floods the water rushes down their valleys and collects in the flatter valleys of the larger streams. The crest of the 1913 flood was caused, not so much by the movement of the water through the main valleys, as by the sudden emptying of these smaller tributaries into the larger streams. It arrived at about the same time at widely separated points on the river, and in some cases where the emptying of the tributaries was particularly rapid, the crest actually appeared at certain points earlier than at other points further upstream on those same rivers. In the valley from Hamilton north there was actually stored at one time during the 1913 flood a third of the entire rainfall of the storm over the tributary drainage area.

This situation should be kept in mind as having a bearing on the cost and feasibility of channel improvement on the Miami; for in order to prevent overflow in the valley in case of a storm

Note. Discussion of this paper is invited, to be received by W. L. Butcher, editor, 14 Beacon St., Boston, before April 10, 1917, for publication in a subsequent number of the Journal.

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like that of 1913, the amount of water to be provided for at any point in the channel must be, not the amount which passed by that point during the crest of the 1913 flood, but the 1913 discharge plus the water which was actually stored in the valley above that point.

The surface soil of almost the entire watershed is glacial till, or clay, sand and gravel, ground up and deposited by the glaciers, but not sifted or sorted, as frequently is the case with glacial drift. As a result, the surface is compact and fairly resistant to the rapid infiltration of water.

The Miami Valley is not to any material degree an alluvial river plain. Before or during the glacial period the valleys of its rivers were scoured out to great depths, and then, with the retreat of the glaciers, the great gorges were filled with débris. In making borings at our dam sites we find rock exposed on the valley sides, but on the valley floor, borings nearly two hundred feet deep do not reach the bottom of the glacial débris. In some places the ancient paths of the rivers are entirely wiped out and covered with high hills of glacial till, while the present valley follows a new path over the former hilltops.

The Miami River of to-day in its ordinary condition is a puny stream winding its crooked course back and forth across the empty bed of a mighty glacial river. It has dug for itself a little channel, large enough, it is true, to carry the ordinary flow, but wholly insufficient for floods. Table 1 shows the capacity of the unimproved channel outside the cities, compared with the flood flow of 1913. At no point will these streams carry a fifth of the flood flow. Within the cities the channel is larger, but still inadequate.

Many people are of the opinion that when the Lord made the earth he had the comfort and convenience of men particularly in view, and that therefore if a river overflows and causes damage, men must be to blame; they must have obstructed the channel or have occupied the area which rightfully belongs to the river. As a matter of fact, a river is an accidental affair — simply the path water follows when it answers the call of gravity. Long repetition commonly results in the digging of a definite channel, but this is not always the case. The Little River in

TABLE 1.

Present Channel Capacities at Various Locations in the Miami Valley Outside of Towns and Cities, Compared with the 1913 Flood Discharge.

Stream.	Location.	Channel Capacity. Second-Feet.	Flood Discharge. Second-Feet.	Ratio. Per Cent.	Drainage Area. Square Miles.
Mad River......	West of Springfield.....	5 000	55 400	9.0	488
Stillwater River..	Above West Milton.....	7 000	86 200	8.1	600
Loramie Creek...	Northwest of Lockington	1 600	25 600	6.3	208
Miami River.....	Below Dayton..........	25 000	252 000	9.9	2 598
Miami River.....	Below Miamisburg......	35 000	257 000	13.6	2 722
Miami River.....	Below Hamilton.........	25 000	352 000	7.1	3 672
Twin Creek......	West of Germantown...	3 000	66 000	4.5	272

Missouri, for instance, with a drainage area of about 2 000 sq. miles, absolutely loses its channel and spreads out over great wooded swamps. Most rivers are either underdone or overdone. Take the upper Colorado, for instance. There is a river channel dug so deep that the greatest flood can fill but a small portion of it. The lower Mississippi, on the other hand, never was large enough to carry its flood waters, which cover the lowlands for many miles from its low-water banks. The Miami River channel, like so many others, is large enough to carry only a very small part of the flood flow, and it is left for men to master the unfinished works of nature.

Floods are not a new experience on the Miami. In 1805, some fifteen years after Dayton was settled, one occurred which probably was not exceeded until 1913, although we do not know the comparative discharges of these two floods. That of March, 1913, reached an elevation nearly ten feet higher in Dayton, but it may be that at the earlier date, the valley near the city had been cleared of forest for agriculture, making an excellent flood channel, while few buildings had been erected to obstruct the flow.

Neither do we know which was the greater rainfall. In the wilderness days, vast areas of swamp land held back tempo-

rarily great quantities of water, while the brooks and depressions were choked with fallen trees and underbrush. Moreover, an army of engineers had been at work constructing reservoirs on all the headwaters. In our discussions of the probable increase or decrease of floods we seldom give proper weight to the work of the beaver. In newer countries I have seen the headwaters of streams so thoroughly controlled with beaver dams that perhaps twenty per cent. of entire watersheds of small streams was formed into beaver ponds. As the dams were abandoned they usually broke in the stream beds, leaving true retarding basins above, which held water temporarily during floods. But as to these earliest floods, we can do little more than guess, and in the absence of definite data it would be rash to say that the rainfalls which caused them were less than that of March, 1913.

The Flood of March 23–27, 1913.

Through the heart of Dayton the 1913 flood was about ten feet higher than any that had occurred for one hundred and twenty-five years. It probably will stand out as one of the great floods of the century. During and immediately after it, Mr. John H. Patterson, president of the National Cash Register Company, did heroic things. At his factory, boats were built at the rate of one every fifteen minutes to rescue those in danger of drowning or burning. Afterward Mr. Patterson financed the city during its period of stress, and in numberless ways furnished those elements of orderliness and purpose necessary to help the city to react in the wonderful way it did. Governor Cox appointed citizens' relief commissions over the state, and they were given powers through quickly enacted state legislation.

The relief commissions appointed flood prevention committees from among their numbers, and it was these flood prevention committees which undertook the problem of preventing another disaster.

It was at this point in the situation, early in May, 1913, that I was first called to Dayton. I found tremendous determi-

nation to stop floods, a feeling that the railroad and city bridges must be to blame and a conviction that dirt must be flying by Fall. There was also a desire to divert as much as possible of the expense to the federal government.

The flood prevention committee was informed, first, that they probably had overestimated the effect of local obstructions upon the flood situation and that the problem probably was not so easily disposed of as they had supposed; second, that no plan of improvement should be adopted without a thorough analysis of the situation, that six months probably would pass before even a provisional solution could be offered, and probably a year before definite plans would be made; third, that federal aid might probably be a will-o'-the-wisp, and that if they wanted flood control they should make up their minds to get it and pay for it, for otherwise they might repeat the history of Pittsburgh and other ill-fated cities which had waited for help.

It is remarkable that in half a day the policy of the flood prevention committee was reformulated and defined, and arrangements made for working out the safety of Dayton and the Miami Valley. The flood prevention committee saw the possible need for coöperation with other cities, and prepared channels of intercourse if they should be needed. I have never met a group of men so quick to see the point, to make accurate appraisals and to define sound policies. The progress made toward flood control in the Miami Valley is due largely to the members of this committee and to the people of the city, who believed in them and backed them up. The committee, seeing that it takes money to get results, in a remarkable campaign of two weeks in the devastated, mud-soaked city raised a fund of $2 150 000 from 23 000 subscribers, as a beginning toward flood prevention.

One of the happiest results of the flood and of the heroic work following was the breaking up of lifelong prejudices and clans, and the welding of the city into a fellowship of progress. The present city manager government of Dayton, while considered before the flood, is really one of the by-products of this change.

Preliminary Investigations.

The task of working out plans for flood control was assigned to the Morgan Engineering Company of Memphis, Tenn. Field work was begun within two days, in two weeks about fifty engineers were engaged in field and office, largely recruited from flood prevention projects in the southern states, and this force was further enlarged during the course of a month.

The work was begun on the principle that no method of improvement should be adopted which had not been thoroughly tested by comparison with every other method or combination of methods. It therefore became necessary to investigate at one time every method of relief which offered even the least hope, and to collect data bearing on every phase of the problem. Field surveys and office investigations were organized on this basis. We investigated channel improvements, channel cut-offs, diversions into other watersheds, levees and reservoirs. Retarding basins as finally worked out were a development of the investigations into storage reservoirs. Personally, I believed we would find our way out by means of channel improvements, and the investigation into control by means of dams was undertaken from a sense of duty, in order that no possible method might be overlooked.

The very first field work consisted in marking and recording the high-water marks as pointed out by residents along the rivers, and in recording their statements as to the time of the flood crest. The chief fact brought out by the hopelessly conflicting records secured is that the average untrained person is extremely unreliable in observing even the most obvious phenomenon. The high-water profile was later worked out with accuracy by engineers who carefully examined water marks on trees and on the insides of buildings, and the time of the passing of the flood was determined closely at a few points by persons who made definite written records at the time. One of the most important parts of the early field work was the estimation of the actual discharge of the principal streams at the crest of the flood.

While the field work was under way, the field notes were platted, and other investigations were carried on. All available

data were secured as to roads, railroads, artificial drainage and the locations of city improvements. A careful study was made of the rainfall of the 1913 flood, and of previous floods on the Miami. An investigation to locate and study every existing record of important rainstorms in the United States east of the arid regions occupied a force of four men for nearly a year.

Run-off investigations were made at the same time. Rainfall and stream gaging stations were established in all parts of the Miami drainage area. Daily reports are received from all of these, and hourly reports during floods or heavy rains. A thoroughgoing system of flood warnings is maintained. This will be especially useful during construction. Flood stages can be foretold within close limits from the rainfall records, twelve hours or more before their occurrence.

Experimental plots of ground were marked off representing hill land and flat land, both in grass and in cultivation, and the entire run-off from them is caught in subterranean tanks set at the lower corners of the plots. Comparison of this run-off with rainfall collected in rainfall gages at the same location gives valuable data and confirms the data secured on a larger scale from stream gagings and general rainfall records.

One engineer was employed for a year in New York and Washington libraries, translating and extracting European literature in German, French and English dealing with flood control, rainfall, dam construction and hydraulic problems. A most thorough investigation was made of formulas for velocity of water in open channels, both in the literature of the subject and by very carefully conducted experiments.

Measurements of the 1913 flood flow were most interesting. They were made by two entirely separate methods. First, the flood plane was taken as a channel, and formulas for the flow of water in open channels were applied. The surface slope was closely determined by marks on the insides of buildings, and by picking away the outside bark of trees, uncovering the muddy deposit beneath.

For the channel section, Kutter's formula was used, the adopted roughness coefficient being based on my judgment, founded on former measurements, checked by other members of

our force. The roughness factor was fully determined before measurements were calculated, so there would be no unconscious "fudging" of results. The results of these two entirely different methods of measuring the flood flow varied by less than 10 per cent. Similar measurements and checks along the rivers and tributaries have convinced us that our results are within 10 per cent. of accuracy.

Tentative Results.

At the end of six months of work we had arrived at certain conclusions. Among them were:

That a larger flood than that of 1913 must be guarded against. At that time we were inclined to hold that a flood 50 per cent. greater should be our criterion. Later, on further study, this was reduced to 40 per cent.

That channel improvement, if at all feasible, would be very difficult and would have very serious drawbacks.

That all methods except channel improvement, cut-offs locally at Dayton, and retarding basins, were entirely out of the question.

That the Mad River could be diverted into Little Miami, but that such a course would only transfer the difficulty.

That retarding basins apparently were feasible, at no greater cost for saving the valley as a whole than would be the cost of channel improvement for Dayton alone.

That more data were needed before definite conclusions could be reached.

That the problem was one for the valley as a whole and not for each locality working by itself.

That united support from the whole valley was needed.

That there was no law in the state under which the work could be done.

Building a Flood Control Statute.

The work could not be constructed without a law to work under. The undertaking being in the hands of engineers, the problem of preparing a law was approached from the engineer's point of view. I first made a schedule of all the results that, from an engineer's standpoint, such a law should make possible. Some of these considerations were:

There must be wide freedom of action to carry out any type of improvement and to do any reasonable thing which should be required by plans for flood control.

As the most efficient and effective agency in our country to-day for getting things done is the corporation, it seemed that such improvements should be handled under corporate forms and management.

There must be absence of politics.

A flood-control organization must have governmental powers — as, right of eminent domain, police power, taxing power, etc.

It must fit without friction into existing governmental machinery.

It must make possible all methods of coöperation with corporations, cities, counties, with the home state or other states and with the national government.

It must be fair and not arbitrary.

It should provide control over stream obstructions and over the ownership and use of water.

It must be a general law, suitable to any situation, and so comprehensive that it will not need amendment to fit some other situation that may arise in some other part of the state. (Special laws are not constitutional in Ohio.)

All these needs and many others were covered in the bill that was written. The experience of the Morgan Engineering Company in handling from seventy-five to one hundred water-control projects under fifteen or more state laws, each one with its legal difficulties to overcome, gave a background of experience. American and European water-control laws were carefully examined section by section to see whether some other situation had developed legal provisions which might some time be needed in Ohio. The engineer scorns being bound by precedent, but not so the lawyer or the courts. And so for almost every provision of the bill some good precedent was found in some law of some other state, in order, as Tom Sawyer would say, to do it in the regular way.

The law provides for the organization, upon the petition of landowners, of conservancy districts, these districts to be in effect both political subdivisions and corporations, governed by boards of directors, who have the powers both of the directors of corporations and of governing officers of political subdivisions.

These officers, appointed by a court, so as to be as nearly as possible free from politics, are as unhampered in their work as the directors of a manufacturing company, but have the powers of the governing body of a city or county, so far as flood control is concerned. There is abundant provision for the acts of the board of directors to be reviewed on their merits by the courts.

The engineers furnished the substance and general structure of this law, but it is to the credit of the attorneys of the district that it was so well drafted into form and so carefully guarded that it has been upheld fully by the supreme court of the state. There were many conferences before the things the engineer said must be done were so stated that the constitutional lawyer said they could be done. Then we finally went over the bill in great detail to see that it was as good an example of English and of clearly expressed purpose as it was of law and of engineering.

The bill had a stormy time in the legislature, but was passed, and later sustained intact through another legislative session. Opponents of the law claimed it to be a covert scheme of water-power interests.

It is unnecessary to tell how public opinion was awakened and informed and how effort was made to have the valley as a whole, a narrow strip of country, a hundred miles long and a mile or two wide, consider itself as one community for flood control. Many local officials found themselves deprived of the opportunity to spend money for local flood control, and consequently there was opposition. Yet when an effort was made at a following legislative session to amend the law to its detriment, in three days a petition was signed by 87 000 people in the valley, protesting against any change.

Under this law the Miami Conservancy District was organized in July, 1915, with three prominent business men as directors. Mr. E. A. Deeds, chairman of the Dayton Flood Prevention Committee, became president of this board. More than to any other factors, the progress of the undertaking has been due to his unusual insight, almost unlimited energy, enthusiasm and public spirit. The forces of the district are now housed in a beautiful office building given by Mr. Deeds at a

cost of $100 000. In February, 1916, a complete plan was submitted to the board of directors. After approval by the board, the plan was reviewed for two months by the Conservancy Court, consisting of a judge from each of the nine counties in the district, and was finally approved, the judges being unani-

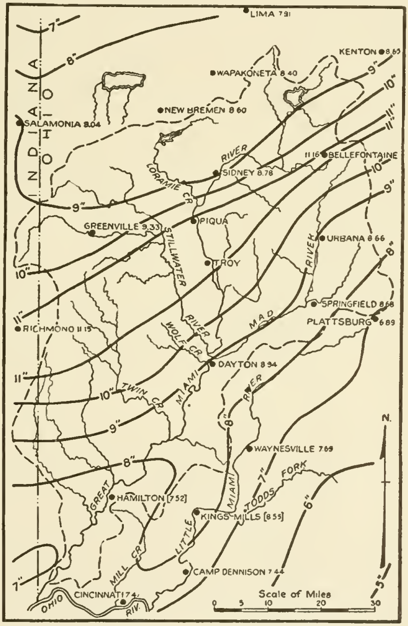

FIG. 1. RAINFALL OF THE STORM OF MARCH 23–27, 1913.

mous on the main point that the retarding basin system, supplemented by channel improvement, is the only feasible method of flood control in the Miami Valley.

PREPARATION OF PLAN.

During all this time the engineering work had steadily progressed. I will briefly review some of the results.

First as to rainfall. A most extensive investigation of flood rainfall is being completed which will be published during the coming year.

It was found that nearly all heavy rainstorms in Ohio came from the southwest. The map (Fig. 1) indicates the rainfall of the storm of March 23–27, 1913, most of which fell in three days. By the way, it appears that in the central United States, a continued intense rain never lasts as long as three days.

The greatest storm so far recorded in this section occurred in October, 1910, and had its center at the southern extremity of Illinois. Nearly all great rainstorms occur during the warm months of the year when the capacity of the ground to hold water is greatest. No winter or early spring rainfall heavier than that of March, 1913, has been recorded east of the Mississippi and north of the Gulf or South Atlantic states.

It was decided to base protective works on an assumption of a flood 40 per cent. greater than that of 1913. This would require a summer rainfall perhaps 60 or 70 per cent. greater than 1913. In view of our limited knowledge of rainfall, it was decided to build dams safe against a flood twice as great as that of 1913.

Relation of Rainfall to Run-off.

During the 1913 flood, about 87 per cent. of the rainfall ran off and the storage in the river valleys during the crest of the flood was about one third of the total rainfall.

Summer rates of run-off are much lower than winter rates. At any one time the surface soil of the Miami Valley has capacity for temporarily storing about $2\frac{1}{2}$ ins. of rainfall. During the summer this storage capacity is quickly made available by evaporation and transpiration of plants.

Most painstaking comparisons were made of various velocity formulas. The results of this investigation are being prepared for publication. Kutter's formula, on the whole, stands the tests better than any other, and when used with good judgment and carefully made observations is a dependable engineering aid. A large part of the published observations of stream flow for the use of the formula are so faulty in theory

and in execution as to be nearly valueless. The loss of head at bridge openings and around bends in channels was investigated and will form the subject of a technical report.

In investigations of scour and deposit by running water it was found that velocities of 8 to 10 ft. per second do little damage in the Miami River, but that velocities of 14 to 15 ft. are seriously destructive. In new cuts, exposing soils not worked over by the river, velocities of 6 ft. per second are very erosive.

Comprehensive and thorough tests have been made of the materials of construction. The limestones, sands and gravels of the valley were made into concrete and thoroughly tested. Much of the limestone commonly used for aggregates is slightly oil-bearing and makes poor concrete. The gravel has been thoroughly tested by glacial action and is very satisfactory. All our sand must be washed to develop its full strength.

GEOLOGICAL SCALE, SOUTHWESTERN OHIO.

- SILURIAN
  - Niagaran
    - Cedarville
    - Springfield
    - Laurel
  - Clinton
    - West Union*
    - Osgood (Niagara Shale)
    - Dayton
  - Medina
    - Brassfield (Ohio Clinton)
- ORDOVICAN
  - Cincinnatian
    - Richmond
      - Elkhorn
      - Whitewater
      - Saluda*
      - Liberty
      - Waynesville
      - Arnheim
    - Maysville
    - Eden
  - Trenton

NOTE. * Indicates formation not found locally. ( ) Indicates name frequently used locally.

FIG. 2.

The geological scale (Fig. 2) covers all the formations met with on our construction. The conduits and spillways on four of the dams are founded on the Cincinnatian, consisting of alternating layers of crystalline limestone and of clay or shale. The clay or shale entirely prevents seepage and the development of cavities. The Lockington spillway is founded on Cedarville limestone, which may have cavities. The geological range is from the Ordovician through the Silurian. In the gravel of the drift there is a large amount of glacial-borne granite of Canadian origin.

An elaborate system of borings and test pits has fully developed the foundations for the dams and spillways, and the location of suitable material for earth dams and for concrete construction. Definite mechanical analyses of these materials have been made.

Investigations were made as to the possibility of flood control by means of many small basins instead of a few larger ones, but relief by this method was found to be impracticable.

Check dams to restrain gravel in its movement downstream were investigated, and may be built later in a limited way on tributaries emptying within or near cities.

Channel improvement as a sole method of relief was found impracticable because of enormous first cost, high cost of maintenance in the shifting gravel river beds of the district, the great damages which would result from channel enlargement in cities, and the increase in discharge which would result from eliminating the valley storage such as existed in 1913.

Storage reservoirs such as those recommended at Pittsburgh were rejected, because the same space cannot be made to serve acceptably for both storage and flood control.

The Plan.

The plan finally adopted consists of a system of five retarding basins, located on the principal streams, supplemented by limited channel improvement through the cities. The dams which form these retarding basins are so designed as to let pass as much water during flood as can be carried safely through the cities below. There are no gates or other regulating devices.

TABLE 2.

DIMENSIONS OF DAMS AND APPURTENANCES.

	Germantown Dam.	Englewood Dam.	Lockington Dam.	Taylorsville Dam.	Huffman Dam.
Length of crest of dam, feet	1 210	4 660	*6 400	*2 980	*3 340
Thickness of dam at average elevation of valley floor, feet	650	740	410	390	380
Number of conduits	2	2	2	4	3
Total sectional area of outlet conduits, square feet	182	214	158	1 116	705
Maximum discharge of conduits in 1913 flood, second-feet	9 340	11 000	8 630	51 300	32 600
Length of spillway crest, feet	55	100	72	132	100
Yardage of earth in dams	865 000	4 000 000	1 135 000	1 235 000	1 655 000
Yardage of concrete in dams and appurtenances	20 000	38 000	38 000	47 000	40 000

* Including spillway crest.

TABLE 3.

TOTAL RUN-OFF IN INCHES WHICH WILL JUST FILL BASINS TO SPILLWAY LEVEL IF ENTERING DURING THE RESPECTIVE TIME-INTERVALS SHOWN.

Basin.	0 Days.	1 Day.	2 Days.	3 Days.	4 Days.	5 Days.
Germantown	7.30	8.45	9.60	10.75	12.13	13.51
Englewood	8.99	9.56	10.13	10.70	11.38	12.06
Lockington	6.68	7.78	8.87	10.00	11.31	12.62
Taylorsville*	4.42	6.12	7.82	9.51	11.52	13.57
Huffman	4.66	6.28	7.90	9.52	11.47	13.42

* Taylorsville figures are for the area of 778 sq. miles above the Taylorsville dam and below the area of 355 sq. miles above the Lockington and Lewistown dams. In making the computation it was assumed in each case that the Lockington basin was filled exactly to the spillway level.

The Germantown dam (Fig. 3) is short and high and causes flooding in a narrow valley. Its spillway and conduit are separated, this being made necessary by the topography. The Huffman dam is of another type, being long and low and causing

flooding to a shallower depth over a broad area. It has a combined conduit and spillway.

The economic balance is reached in the design of a retarding basin dam and its outlets when the water in the basin just reaches the spillway during the most extreme flood. If the water does not reach the spillway under such conditions, the capacity of the basin is not being fully developed. The capacity of the conduits in such case might better be restricted further, so as to give more complete protection below. On the other hand, if water flows

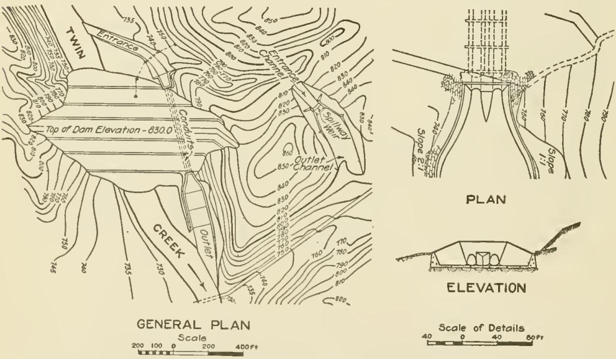

FIG. 3. THE GERMANTOWN DAM.

over the spillway to any appreciable extent, the flow over the spillway is being added to the maximum discharge through the conduits, creating a short secondary crest in the channel below. In such case it would be better to enlarge the conduits, allowing a somewhat larger flow throughout the whole flood, thus keeping enough storage space available to prevent the short secondary crest due to overflow of the spillway. It was first thought that a spillway with an earth crest which would wash out like a movable dam would give an added factor of safety to the dam. But this was abandoned in favor of greater freeboard on the dam, because of its tendency to produce a secondary flood crest.

In general, the dams are designed so that this maximum

efficiency is reached in case of a flood 40 per cent. greater than that of 1913, representing a run-off of ten inches in three days. If a flood 60 per cent. greater should occur, the efficiency of the system would not be quite so great, because of the secondary crest due to overflow over the spillway. This policy of having the maximum degree of control in case of a flood 40 per cent. greater than that of 1913 could not be adhered to in case of the Germantown and Englewood dams, as the necessity of having the dams safe in case of a flood twice as great as 1913 in these cases results in giving these basins their greatest efficiency in a flood more than 40 per cent. greater than 1913.

It has been objected that retarding basins are an innovation. The Rhine at Lake Constance, the Rhone at Lake Geneva and the Po at Laga Maggiore have their flood flows reduced to a very small fraction of the inflows into these lakes. In Germany and Austria, in recent years, extensive systems of retarding basins have been constructed.

In the United States, the Little River Drainage District uses the principle to reduce by a half a flood flow of more than 100 000 second-feet. At Harrisburg, Pa., and at Watervliet, N. Y., the system is in use on small streams. While the particular assemblage of parts adopted in the Miami Valley has no precedents on a similar scale, yet every element has been thoroughly tested on as large scale in other constructions.

Some Problems Encountered.

Many interesting problems have been worked out in the preparation of the plans. One of the most interesting is the method of destroying the velocity issuing from the conduits under a high head. In considering this problem, an experimental plant was constructed, duplicating the Germantown conduit outlets on a one-sixteenth scale, and using velocities one fourth of what would exist in the actual construction. Baffles somewhat like those at Gatun* were tried and found to be very ineffective. A part of the water weaves its way between the baffles like a snake crawling between stalks of shrubbery. After a year's experi-

* Journal B. S. C. E., Vol. 3, p. 135.

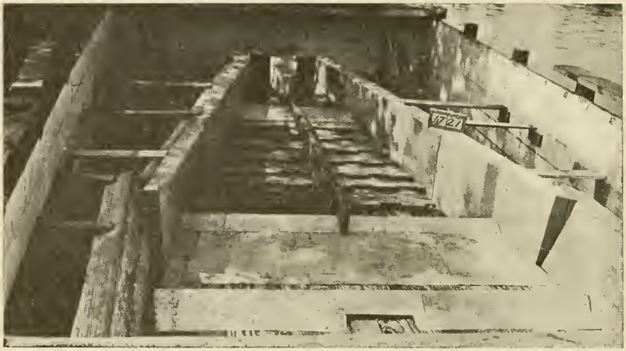

Fig. 4. Type of Outlet from Conduits.

ments the type of outlet shown in Fig. 4 was chosen. The water emerging from the conduit falls down the inclined plane and meets a weir over which it must pass. Back water from below tends to pile on top of it and a standing wave is created, destroying the velocity energy by internal friction. A view of the standing wave in action is shown in Fig. 5.

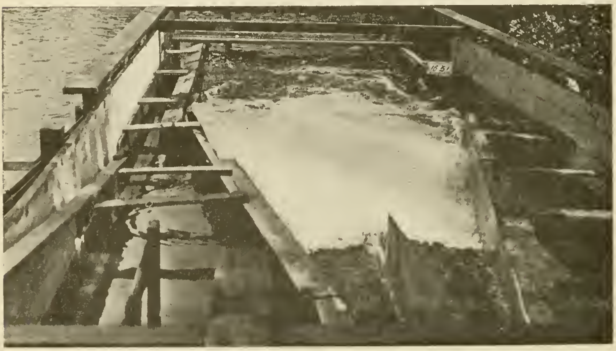

Fig. 5. Standing Wave at Foot of Outlet.

The causes of earth dam failures were thoroughly studied in detail. While failures of poorly designed dams are numerous, in nearly every case the cause was found to be one of the following: Overtopping, sliding of slopes, leaking through the dam, seepage under the dam, wave action, back lash from the outlet below the dam, seepage along conduits, failure or settlement of outlet works, burrowing animals, malicious acts or neglect.

We have taken up these causes of failure one by one, and have so designed our works that we believe we are absolutely safe against failure from any one of these causes or from any other short of a great earthquake or some other cataclysm.

The responsibility for the safety of the work has rested heavily upon the engineers. That is the reason why the factors of safety chosen are so enormously large, why the structures have been made massive to the point of being open to serious criticism, and why every least detail has been painstakingly worked out, as though the safety of the entire system depended upon that detail.

And all through the design our patron saint has been — not the Greek architect who could design a beautiful structure, graceful and slender, but rather Pharaoh, who built his pyramids on so broad a base that no matter what mistakes of judgment might be made, or how faulty work might be done in the building, they would yet stand through the thousands of years.

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PAPERS AND DISCUSSIONS

DISCUSSION OF "THE GROINED ARCH AS A MEANS OF CONCRETE FLOOR CONSTRUCTION."

By Messrs. Charles R. Gow, Frank L. Fuller, E. F. Rockwood, Allen Hazen, John R. Nichols and H. Whittemore Brown.

Mr. Gow.* — I am disposed to feel that there is a great deal of merit in the suggestion which the author has brought forth in this paper. From my experience with this form of construction, I have been very much impressed with the strength and the possibilities in the use of the groined arch. For example, in the construction of the Springfield filters to which the author referred, we had a crown thickness of 6 ins. and a 13-ft. span, with a depression over the columns, as is customary in such work, for economy. We found it was possible to support our operating derricks on the roof with hoisting engines and other apparatus. At first we were rather timid, and always placed the loads over columns, but as time went on and nothing happened we became bolder and subsequently would place the foot block of the derrick or land the engine at any point, on the crown or elsewhere, and at times there would be a concentrated load of perhaps eight or ten tons under a derrick support, and during the entire construction there was no sign of weakness. We often had occasion to drive over the roof with loaded teams, and while the specifications called for a protecting covering of a few inches of earth, we did not always get it, and it was a common occurrence to have a loaded team weighing three to four tons

* The Charles R. Gow Co., Contractors, Boston.

roll over the crown of these arches and perhaps over a good-sized cobblestone and bang down again, and even under that rough usage there was never a single instance of failure or cracking. It became apparent, therefore, that this method of construction, if adequately supported against lateral spreading, was exceptionally strong. We were, of course, always apprehensive of the danger of a failure due to spreading by reason of the premature removing of the supports at either end, or a failure sufficiently to back up the abutments, and, on at least one occasion, we had a near failure due to stripping forms too close to the working end. It was our practice to keep at least three bays of forms always in place under their posting, to insure adequate resistance at that point.

About a year or so ago, we had a similar piece of construction at Lowell, Mass., and in the case of part of the work had a special design of roof, that is, the spans were not standard and it required a separate set of forms. This work was not extensive enough in volume to warrant a large outlay for forms, and we found progress very slow because we had to keep so large a percentage of the forms in place as a support for the thrust action. At the suggestion of Mr. Frank A. Barbour, a member of our Society, who was consulting engineer for the City, we reinforced the squares of the roof about each column with four ½-in. round bars, and when I refer to squares I mean the square formed by the four sections of forms which surrounded each column, — in other words, a section of column and roof which resembles an umbrella turned partly inside out. These squares were used as concreting units, and it was our practice to place the four ½-in. round steel bars on the perimeter of that square. We then found it was possible to drop the forms entirely after the concrete had set. We didn't do this in the beginning, but as we grew bolder we reached the point where we would take away every bit of form and set it ahead, leaving the last half arch cantilevering out from its column. During the entire work there was no sign of stress. The self-supporting quality in the arches apparently resulted from a double action of cantilever and circumferential hooping, producing a form of ring tension.

With regard to the cost of the forms that the author has noted, I find it was true that in the case of the Springfield work the arch forms cost four and one-half cents per square foot. In the Lowell work, which was not quite so extensive, they cost six cents. The bulk of this increase was undoubtedly due to the time that had elapsed, — I think some seven years, — and I have no doubt if the same work was to be done to-day it would cost very much in excess of the higher figure, carpenters' wages having increased materially as well as that of unskilled labor, with some increase also in material costs. I think, however, that the relative cost of various types of forms would presumably remain about the same.

It is true that groined arch form work is very much cheaper than is usually supposed. It looks complicated on paper and also somewhat complicated after it is constructed, but nevertheless if the work is intelligently executed it is a very economical and simple type of form work. One of the reasons for this economy is the facility with which the sections of groined arch forms can be erected, removed and used over a large number of times, which, generally speaking, is not true of beam and slab or mushroom type of construction, the form work of which ordinarily is largely or entirely dismantled before it is put together again. The groined arch forms can be erected and removed intact, with very little repair, and there isn't the same waste of lumber. The specially curved form sections used in groined arch construction are practically worthless for any other purpose and are therefore not diverted to various uses, as is the case with other types of forms after they have been dismantled.

Until to-night, when I heard the speaker say that he had designed a span of 20 ft. (I think he said 20 ft. x 20 ft.) with a total rise of 25 in., I had wondered if this type of construction wouldn't be prohibitive on the large spans encountered in ordinary building construction, but, if it is true that it can be accomplished in a vertical distance of 25 ins., these spans may not be as prohibitive as it seems at first glance.

On the whole, I am disposed to believe that the suggestion which the paper brings to us has much practical value, even

though its use be limited to special rather than general application.

MR. FULLER.* — I have covered two open reservoirs with this form of roof and they have been entirely satisfactory. On one at Natick, the only trouble we had was in the sections where the outer part of the arches rested upon the embankment. We had a core wall which we knew nothing about, it having been built a good many years before, and when it became necessary to cover the reservoir, we placed the piers so that there should be a row about midway of the embankment, and the outer edge of course had to rest on the top of the bank, and we excavated far enough to get to this core wall. That didn't prove to be entirely satisfactory. There must have been some slight settlement of the wall, because we had, in places, cracks between the edge of the embankment and the first row of piers, and parallel with them. That was afterwards remedied by building up some supports on the under side from the paving, which was a very good piece of work, and, so far as I know, there has never been any trouble since, but in the entire roof within the four lines of piers I never saw any cracks or any settlement or any trouble whatsoever. In the case of a heavy rain, a slight leakage occurred, where different sections of concrete joined, but that we didn't consider as anything serious and made no special effort to stop it. As in Mr. Gow's instance, the roof was subjected to very hard usage. It wasn't completed till rather late in the season, and a few inches of earth was put on to protect it from the frost, and after a heavy rain we had some very cold weather before the material was spread very much. Of course it was dumped by carts and spread a little. These carts went right over the concrete, but some of it had not been laid very long and was not entirely dry. The material was left in ridges more uneven than the furrows of a field. It was thought desirable to finish the covering that season and a new covering had to be put on over the frozen material. By building a runway and using block and falls to help up the teams, very heavy loads of earth were carried on to the roof and of course had to be driven over it and taken to different parts. It was extremely rough,

* Civil Engineer, Boston.

and those teams went bumping over that frozen material in a manner which made one almost feel that something would give way, but it never did and the roof has stood perfectly well. At Wellesley we covered a similar but smaller reservoir in the same way. There I arranged the piers so that they should come nearer to the edge of the bank, and we had less width and less weight of concrete between the outer row of piers and the top of the bank, and so far as I know there have never been any cracks in that reservoir roof. Two years ago we built a covered reservoir for the town of Webster, using the flat slab construction, which also was very satisfactory and gave no trouble whatsoever. I have never figured out the comparative cost of the two methods, but I do not believe they would vary much. In either of these cases it would be difficult to know just what the cost per square foot of centering was, because the cost was included in the price per cubic yard of concrete of which the roof is composed, but, as has been said, the groined arch centers are not very difficult to make and they can be used over and over again and can be removed after having been sufficiently long in place with little damage. I think that although there would be perhaps more carpenter work in a given surface, or a given area, the fact that these centers can be used over and over again, and the fact that probably in flat slab construction it would be better to center the whole reservoir (I don't know how it would be in a building), the cost of the two methods of centering might not be very different.

The old Natick open reservoir, with sloping embankments, outside and in, was covered in 1902. There are thirteen rows of piers, with thirteen piers in each row, or 169 in all. Piers are 15 ft. 2 ins. on centers and are 20 ins. square above the base. The area of the roof is 44 700 sq. ft. and the capacity of the reservoir, 4 280 000 gals. The elliptical arches used in the design of the roof have a span of 13 ft. 6 ins. and a rise of 2 ft. 9 ins. The thickness of the concrete roof at the crown is 6 ins. and over piers, 3 ft. 3 ins.

Twenty-two hundred barrels of Atlas cement, 200 of Brooks-Shoobridge, and 200 of Alsen American Portland cement, or 2 600 barrels in all, were used. The concrete was composed of

one volume of cement, two and one half of sand and four and one half of screened gravel, mixed very wet.

Concrete for the roof was put on in sections 30 ft. 4 ins. wide, and of a length equal to the width of the reservoir, the joint being along the crown of the arch. Through this joint there was some leakage in times of heavy rain, but this caused no particular harm.

The minimum time allowed for removing pier forms was about four days. Generally they were allowed to stand longer. The minimum time allowed for removal of roof centers was ten days. In some cases they remained two weeks or longer, or until needed.

The work was done by contract by Mr. F. A. Snow, of Boston.

The cost of concrete on the bottom	was	$8.50 per cubic yard.
,, ,, ,, ,, in piers	,,	9.50 ,, ,, ,,
,, ,, ,, ,, ,, roof	,,	12.50 ,, ,, ,,

Total amount expended in reservoir improvements, $30 116.75.

Mr. Rockwood* (*by letter*). — The writer has read with a good deal of interest the paper on the groined arch as a means of concrete floor construction and it would seem to him that one very serious drawback to this type of construction would be the difficulty in attaching inserts to the forms or hanging shafting, piping, etc., from the under side of the slab.

In regard to the cost, the writer would question whether the costs given for this type of construction as compared with beam and slab or mushroom construction are both based on the same conditions, whether the unit prices for materials and labor were the same, whether the story heights were similar, whether the forms were used over the same number of times, and whether both costs included initial cost as well as erecting, stripping, etc.

Mr. Hazen† (*by letter*). — The writer is pleased to see a discussion of the use of the groined arch in ordinary floor construction. Long experience with it in covers for filters and pure-

* Chief Engineer, New England Concrete Construction Co., Boston.

† Consulting Engineer, New York.

water reservoirs leads him to believe that there is much merit in the suggestion.

For one thing, it puts all the concrete in compression and develops that admirable quality of concrete in the most advantageous manner. Reinforcing is unnecessary, except that a moderate amount of reinforcing may be convenient during construction in permitting forms to be more quickly moved forward and to serve afterwards as an additional precaution against failure under extreme unequal loading, or in case of slight movement by settlement of foundations or otherwise.

As the author points out, the cost of the forms is probably no greater; it even seems to be less in some cases than the cost of forms for slab and beam construction. The volume of concrete, also, with a good groined arch design is surprisingly small when compared with that required for slab and beam construction, and the absence of reinforcing is an unbalanced item of cost in favor of the groined construction. The thrust of the concrete arch must be adequately provided for, and when this is done the groined arch is extraordinarily strong. This is demonstrated by tests such as those made by the author and also by wide practical experience.

The difficulty of computing the stresses in a groined arch is great, and this difficulty has no doubt tended to retard its adoption, because designers have been reluctant to adopt a type of construction, the stresses in which they could not compute with a reasonable degree of certainty, even though practical experience with it was favorable.

The writer has given this question of stresses much consideration. Probably the safest general method is along the lines referred to by the author and attributed to Mr. Horace H. Chase, but the writer has carried it a little further. The whole arch, instead of being divided into quarters, may be divided into very narrow radial segments, each joining and opposing an equal and opposite segment springing from the next pier. Computation made in this way neglects the obvious fact that some of the segments are stronger than others, the strongest ones being on the straight lines between the piers and the weakest ones being the diagonal ones, and that the general stiffness of the

structure will partially transfer some of the surplus strength of the straight arches to the diagonal ones. Neglecting this consideration, the unit stresses in the diagonals will be just twice as great as they are in the shortest arches between two piers.

This suggests a practical short-cut method of estimating stresses which the writer has followed and which has seemed to be safe in his work.

First, the radius of a circle is found, having approximately the same curvature as the arch at the top on the short line between two piers. The elliptical form of the interior has been always used in our work. There is no theoretical reason for using the elliptical form, but in the analysis of stresses that we have made by various methods, and the following endeavor to draw an arch to best fit them, the shape found has worked out to be so near an ellipse that there was no reason for departing from it. The use of the ellipse makes laying out easy and calculating volumes easy, but that is not a sufficient reason if the analysis indicated any other form.

With an elliptical interior the radius of a circle of equal curvature at the top is the square of the half span divided by the rise.

The exterior of the arch in our work, ordinarily parabolic, has a somewhat greater radius of curvature at the top, ordinarily from 10 per cent. to 20 per cent. greater, and in a general way the radius of a circle of equal curvature lying in the middle would be from 5 per cent. to 10 per cent. greater than that of the ellipse forming the lower surface.

The unit pressure at the top of a cylindrical arch is the weight of a unit of unit area multiplied by the radius; for instance, if we have 6 ins. of concrete weighing 75 lbs. and 2 ft. of earth weighing 200 lbs., and with a small allowance for other occasional loads, making a total of 300 lbs. per sq. ft., and if the average radius of curvature is 20 ft., the thrust at the top (assuming it to be a cylindrical arch) is 6 000 lbs. per linear foot, or 12 000 lbs. per sq. ft. on the half square foot of concrete exposed in one linear foot of arch, equal to 83 lbs. per sq. in. on the whole area. On the diagonal section, this thrust will be doubled, and will amount to 166 lbs. per sq. in.

It is then further assumed that the whole thrust is not equally distributed on the whole area of the concrete, but that it is concentrated in some measure at one side or the other, and because of this it is probably somewhere double the average, or 333 lbs. per sq. in.

Designs have been made so that, with all reasonable assumptions of temporary and extra loading (not included in the above example), the unit pressures first computed have not exceeded 150 lbs. per sq. in., giving a final ultimate thrust of 600 lbs. per sq. in. at some places. With a radius of curvature at the top of 20 ft., this corresponds to a loading of 540 lbs. per sq. ft.; in other words, starting with the assumptions made above, the design would still be safe with 30 ins. additional earth fill over the whole top, or it would be safe with a smaller unequal loading.

This method of calculation, while empirical, seems to the writer to give reasonable results as tested by all the calculations that he has been able to make and by experience with groined arches designed in this way.

It may be pointed out that making the top of the arches flat, as will be the case in a floor, gives any section which is not heavily loaded a power to act as a strut between adjoining sections that are loaded, in a way that does not exist in ordinary reservoir or filter construction, and such a floor, especially if stiffened with a moderate amount of reinforcing, should be very much better adapted to carry unbalanced loads.

Expansion due to temperature changes may require consideration. In filter and reservoir roofs the barrel arches always used at the sides, and which therefore completely surround the groined arches, permit a slight temperature movement to be taken up. With a flat top carried to the limits, this outlet for movement would not exist, and in large floor areas some other provision might be found necessary.

Mr. John R. Nichols.* — Mr. Brown's adaptation of the groined arch to concrete floor and roof construction in buildings is of interest to engineers at least as an example of the greatly varied possibilities of reinforced concrete. To what extent this type of construction will be used in buildings, the future

* With Monks & Johnson, Boston.

only will disclose. It may, some day, be used in storage warehouses and some types of mills as extensively as it is now used for the roofs of reservoirs and filters. But that will be only after the pioneers of construction with courage or recklessness (only the results can determine which) shall have demonstrated its fitness for such use. For the ordinary loft building or factory, the groined arch floor, whatever may be its structural sufficiency, has a defect that is probably fatal. The groined ceiling is not a convenient surface for attaching motors and shafting, and for this reason manufacturers in general will probably not look upon it with favor.

The writer has in mind, however, one case where the groined arch floor may prove exceedingly useful. This is the case of a building, the foundations of which penetrate through a layer of soft soil to firmer soil below, and the ground or basement floor of which rests upon the soft material. The surface of the ground could then be graded by the aid of templates to the shape of the groined arch soffit, and concrete poured over it, producing a constructed floor supported on firm foundations at a cost only slightly exceeding that of the ordinary concrete paving laid on the ground, which, in this case, would be subject to settlement. At least, it seems likely that the cost of such a groined arch floor would be considerably less than the customary reinforced floor which would otherwise be used to avoid settlement.

In the design of groined arch floors as described by Mr. Brown, it is of course necessary not to lose sight of the bending in the columns occasioned by raising the tie rods to the level of the crown. Provision must be made in the interior columns to take care of an unbalanced live load and in the wall column for the live and dead load.

If we have square bays, columns l ft. apart on centers, and the load in question (live for interior columns and live and dead for exterior columns) is represented by w lbs. per sq. ft., then the bending to be provided for in any given column at its junction with the floor is approximately $\frac{wl^3}{8}$.

This bending moment is divided between the section of the column above and that below the floor in a proportion which

is determined, among other factors, by the relative stiffness of the two column sections and their lengths. The amount of this bending and its distribution in the upper and lower columns are also affected by the distribution of live load not only on the floor under consideration but on other floors of the building as well, and in so complicated a fashion that it is impractical to determine the bending in any given length of column with any attempt at precision. The approximate value for the total bending given above ignores continuity and loading of portions of the structure other than that immediately under consideration, but it probably takes care of the worst cases of loading that are likely to occur.

It is by no means impossible or even impracticable to make provision in columns for such bending. We are constantly doing it in columns supporting flat slab construction, though the moments there are somewhat less in magnitude. But the cost of such provision and the floor space occupied by enlarged columns must offset to some extent the advantages of the groined arch construction for the upper floors of buildings.

The value given above for the bending in columns is also useful in determining the stress in the tie rods of the arch itself, with some reduction in l (the span), to take care of the thickness of the columns. In this case, however, w is always the total live and dead load. If l_1 is the span of the arch and a the vertical distance between the tie-rod (horizontal through the crown) and the center of compression in the arch at the springing, then the total tension in the tie rod (or rods) in one direction pertaining to one column or bay is $\frac{wl{l_1}^2}{8a}$.

In conclusion, the groined arch has now a considerable field of usefulness. With the raised tie-rod introduced by Mr. Brown there is hope that an extension of this field into some phases of building construction may be advantageous. But the process will be slow while the conservative (or timid) wait for the reckless (or courageous) to show them the way.

Mr. Brown.* — I believe Mr. Gow's experiences serve to reinforce my contention that the groined arch is very strong,

*Author's closure.

even under concentrated loads, and without steel reinforcement; although it is true that he used a very much greater crown thickness than I am proposing, he finds that concentrated derrick loads of eight or ten tons cause no distress. These are probably much more severe conditions than we would expect to encounter in building work.

The great advantage gained by the use of small amounts of reinforcing steel in the Lowell filter is also of pertinent interest; in the method which he used, there would seem to be a combination of hoop tension and cantilever action which is somewhat different from that which is the case with reinforcing bands around the sides of the bay, as I have suggested.

The design referred to is as follows:

Using the same ratio of rise to span on a 20 ft. x 20 ft. bay as was used in the test described, the constant multiplier would be $\frac{20}{8} = 2.5$.

That is, it would require 2.5 times the area of steel, the rise and the crown thickness in a 20 x 20 bay, as was required in the 8 x 8 test bay in order to give the same strength in pounds per square foot on the floor.

The total weight of steel in the arch would then be:

As there were two $\frac{3}{4}$-in. round bars used in test floor, there would be required 2 x 2.5 = 5 $\frac{3}{4}$ bars in 20 x 20 floor; length around 20 x 20 bay = 80 ft.; $\frac{3}{4}$ round bar weighs 1.50 lbs. per ft.; total weight = 5 x 80 x 1.50 = 600 lbs., or 1.5 lbs. per sq. ft. of floor.

Volume of Concrete.

Average thickness test arch	= 4 ins.
Average thickness 20 x 20 arch, 2.5 x 4	= 10 ins.
Volume = 20 x 20 x 10/12	= 333 cu. ft.

Dimensions, 20 x 20 Arch.

Rise, 2.5 x 10	= 25 ins.
Crown thickness, 2.5 x 2	= 5 ins.
Total depth at columns	= 30 ins.

The first crack on the test arch occurred at a load of 750 lbs. per sq. ft.; using a safety factor of 3 on this load, the safe load would be 250 lbs. per sq. ft.

Comparing this design with that of a flat slab floor of the same dimensions and for the same loads, i. e., 20 ft. x 20 ft., 250 lbs. per sq. ft. live load:

GENERAL DIMENSIONS.

Slab thickness, 9 ins.
Drop panel, 8 ft. square, 4 ins. thick.
Column cap, 4 ft. 6 ins. diameter at top, 45 degree slope.

VOLUME OF CONCRETE.

Slab, 400 x 9/12	=300 cu. ft.
Drop, 64 x 4/12	= 21 cu. ft.
Cap (excess outside column)	= 11 cu. ft.
Total	=332 cu. ft.

WEIGHT OF STEEL.

Fourteen,	$\frac{5}{8}$ in. square, 30 ft. 6 ins. long	= 567 lbs.
Fourteen,	$\frac{5}{8}$ in. square, 18 ft. 0 ins. long	= 335 lbs.
Ten,	$\frac{1}{2}$ in. square, 30 ft. 6 ins. long	= 259 lbs.
Ten,	$\frac{1}{2}$ in. square, 10 ft. 0 ins. long	= 153 lbs.
Six,	$\frac{5}{8}$ in. rounds, 20 ft. 0 ins. long	= 62 lbs.
Total		1 376 lbs.

which is about 3.5 lbs. per sq. ft. of floor.*

Mr. Fuller's discussion also serves to illustrate the great strength and usefulness of the groined arch.

I admit Mr. Rockwood's contention that the groined ceiling would be open to certain objections from the point of the adaptability of hanging shafting; until some one invents a new way of hanging shafting, we shall be obliged to confine the groined arch to buildings where this difficulty does not obtain.

As to the criticism of the cost data, a little more careful observation of my statements should suffice, i. e., "to be sure, some allowances ought to be made for the increase in cost, due to the height of the buildings; but this [the cost data given in paper] should dispel any fear that the introduction of curved forms materially increases the cost of the form work." I think this statement has been borne out by the statements of Mr. Gow

* I am indebted to the Aberthaw Construction Co. for the slab design given above.

and Mr. Fuller. It was not the object of the paper to give any such careful analysis of costs as contemplated by Mr. Rockwood.

I was very much pleased with the discussion presented by Mr. Hazen, as it not only bears out a great many of my ideas, but also gives a short-cut method of design. Although a proof of his method of design is not given, I believe that it shows that empirical methods of design for arches are not impossible or impracticable. My small experience with flat slab design leads me to believe that results may be obtained with empirical arch designs which will check as closely with the actual conditions as do the results of our variety of flat slab designs.

The consideration of temperature stresses is indeed pertinent. I hope that it may receive attention in the near future.

. Mr. Nichols brings out the same point about the difficulty of attaching shafting, etc., to the groined arch ceiling that Mr. Rockwood mentions, and I shall have to give him the same reply.

The magnitude of the bending moment in the columns emphasized by Mr. Nichols must be considered, but need be no cause for rejection, inasmuch as we are not obliged to keep the rods at the top of the arch. If the bending becomes excessive in the exterior columns (which are the only ones, under ordinary conditions, that would require consideration), the rods extending from the first interior column to the exterior column could be inclined downward enough so that they would counteract the thrust at the exterior at about the position of the resultant thrust, thus reducing the bending to zero. This would possibly require the use of a little extra concrete for fireproofing the rods where they might cut through the concrete of the arch. So long as the rods are straight between columns, even though they are not horizontal, the action remains substantially the same as in the arch which I tested.

The method suggested by Mr. Nichols for computing the stress in the tie-rods contains nothing of a very novel character, inasmuch as the position of center of compression at the springing and at the crown (which Mr. Nichols assumes when he considers the center of the tie-rods to pass through the center of compression at the crown) makes the structure statically de-

terminate. It is the finding of these two positions which involves us in the theory of the elastic arch; when that is done, our problem is practically solved.

The disadvantages of the groined ceiling having been pretty well brought out, let us now consider some of its advantages.

We should not overlook the tendency toward individual drives for machinery, made possible by the introduction of electric power, which, obviating shafting, does away with the greatest objection to the groined ceiling.

Also consider the advantages to be gained in lighting and ventilation by the groined ceiling; a light placed at the center has a natural reflector in the curved surfaces of the ceiling, the absence of beams and girders gives excellent opportunities for ventilation.

The great opportunity for a pleasing architectural treatment to be gained by the proper combination of columns, capitals and the groined ceiling should also be considered, as it is a combination which, through its form and distribution of mass alone, will give a most pleasing architectural effect.

In conclusion, I wish to point the fact that those of my commenters who have had considerable experience with groined arches seem favorably disposed toward my suggestions for their application to floors, while those whose experience with them is of a somewhat limited nature would have to be placed in Mr. Nichols' category of the conservative or timid.

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PAPERS AND DISCUSSIONS

MANCHESTER, MASS., OUTFALL SEWER.

By Raymond C. Allen, Member Boston Society of Civil Engineers.*

(Presented before the Sanitary Section, January 3, 1917.)

The town of Manchester is a small coast town on Cape Ann, Massachusetts, lying between Beverly and Gloucester, having an area of about 8 square miles and a population of about 2 900. Settled about 1629, its growth was for many years slow, and except for a period of about forty years in the middle of the last century, when as a center of cabinet manufacturing it attained national reputation in that line, its history and growth was similiar to that of hundreds of other small communities. Between 1870 and 1880, however, the development of this small town as a summer resort began making possible and necessary many public improvements which otherwise probably would have been foregone. Beginning with Richard H. Dana, the author, followed by Boston families and later by people from the whole country, Manchester, together with other parts of the North Shore of Massachusetts, has become a summer playground of wealthy families.

The original village was largely grouped along the valley of Sawmill Brook, the only considerable stream in the town,

Note. Discussion of this paper is invited, to be received by W. L. Butcher, editor, 14 Beacon Street, Boston, before May 10, 1917, for publication in a subsequent number of the Journal.

* Civil Engineer, Manchester, Mass.

while the estates of the summer residents followed, first, the coast line, and later the hills around the village, overlooking the sea.

In 1892, the town, almost at the point of accepting the proposition of a private water company, after most lively debate and with many misgivings, installed a water system, which was enlarged in 1908. The growth of the town took a new start with this improvement, and with the increasing number of summer estates the population of the village was augmented by the families of servants and mechanics seeking the employment thus provided.

With the introduction of water came, as a natural result, the installation of water-closets to replace the old-fashioned privies of the village. Estates along the shore disposed of their sewage by emptying it into the ocean, while those on the hills about the town in many cases installed filter beds of more or less effectiveness. In the village, however, wherever possible, the drainage of houses flowed directly or indirectly into the main brook and its tributaries, or into old storm drains which eventually discharged into the main brook and the inner harbor of the town. This created a condition which gradually became offensive and at last started an agitation, weak at first, but gradually gaining strength, which sought primarily to better the condition of the village and its stream and harbor. The outcome was a study and report upon a sewerage system for the town, undertaken by Mr. Desmond FitzGerald, who made a thorough and careful report to the town in 1912.

Mr. FitzGerald was very loath to recommend the discharge of sewage into the harbor even at its mouth, and spent a great deal of time and study seeking suitable places for filter beds and similar methods of disposal. Unfavorable conditions of soil, the large extent of the watershed of the water system in the town, and the high value of available land, together with the large resulting damage to adjoining holdings, should such a method of disposal be adopted, led him finally to recommend that the sewage of the town, collected by a separate system of sewers and pumped from a collecting basin at the harbor front, be treated in an Imhoff tank on one of the islands of the outer

harbor, and thence discharged by gravity into the ocean in deep water.

This report was considered by a committee of the town, and the general plan studied by the State Board of Health. The construction of the outfall necessary to reach House Island, the only suitable island, — about one-half mile from shore, — was upon careful investigation found to be in all probability very expensive, and it was finally decided, in view of the comparatively small amount of sewage, to seek a direct outlet into deep water at some point in the outer harbor where no ledge would be encountered in the trench for the pipe and where the construction might proceed with the least difficulty in stormy or rough weather. This proposition was approved by the State Board of Health, and the town voted to proceed with the work and authorized a bond issue of $225 000 therefor.

The system recommended by Mr. FitzGerald and carried out by the town, with the exception of the Imhoff tank at the outfall, consists of a separate system of sewers throughout the village, about eight miles in length, and ranging from 6-in. vitrified pipe to 30-in. cast-iron pipe. Much of the system is below high water, and all such consists of cast-iron pipe. The sewage is collected at a point near the center of the village, on the harbor front, in basins consisting of duplicate tanks of about 60 000 gals. capacity each. From these collecting basins the sewage is pumped, by electrically driven pumps, to a point of discharge in the outer harbor in forty feet of water at low tide.

There is little of interest in the street system of the town, the only unusual features being a great amount of ledge and much water. Owing to liberal use of iron pipe, however, leakage has been kept down to a reasonable amount, although, were the work to be done over, the writer would increase the length of the iron pipe to cover certain portions of the system where the level of the ground water is quite high.

The collecting basins and pumping station offer a few features of interest, and before describing the outfall sewer the write will briefly describe them. The site of this plant was on the shore of the inner harbor, on marsh land the surface of which is at about elevat on 9.5 ft. above low water. Sewage was to

enter at about elevation -1.00 ft. and discharge through about 8 700 ft. of 14-in. cast-iron pipe into the sea, at a depth of 40 ft. at low water.

The design of this plant was made by Metcalf & Eddy, of Boston, in collaboration with Mr. FitzGerald, and the work was constructed under the supervision of the writer. As designed, the floor of the tanks is at an elevation of 12.17 ft. below low water, and the floor of the pump well at an elevation of 15.08 ft. below the same datum.

In the original report, covering this feature of the construction, $35 000 was allowed for the work, including station equipment. Prior to asking for bids upon the work, two test wells or wash borings were made at the site of the work, and it appeared that the structure would be entirely in clay, the upper portions apparently in hard blue clay, the lower in softer yellow clay, and that, further, at some eight feet below the subgrade of the bottom of the tanks, occurred a deep stratum of water-bearing sand.

These findings discouraged bidders, and but two bids were secured, one being $28 177 and the other $33 093. Both were rejected, and the Charles R. Gow Company was employed to excavate a shaft three feet in diameter to a little below the proposed bottom of the tanks, all contractors being given an opportunity to see the actual conditions as the excavation progressed. This work cost $300, and was well done. The results showed that the work would lie in stable blue clay, and new bids were called for.

As a result, the new bids ranged from $15 300 to $33 000, and the contract was awarded to the Charles R. Gow Company, who with little difficulty carried the work to a speedy and successful conclusion.

The sewage enters the tanks through a screen chamber, in which are controlling gates allowing either tank to be used. At one side of the tanks and the screen chamber is located the dry pump well. Here are installed two 6-in., 1 000-gals. per minute, Lawrence vertical centrifugal pumps, driven by 25 h.p. General Electric motors, direct connected and running at 2 300 volts and at 1 800 r.p.m. The pumps, below the level of the

bottom of the tanks, are always primed and are so arranged that either tank can be operated by either pump. The sewage is discharged through a Venturi meter, although as yet the recording apparatus has not been installed. Consequently, in order to secure a record of the flow, two Bristol self-recording gages have been installed.

The operation of the station through nearly two years has shown it to have been well designed, no objectionable odors having been encountered and the purposes for which it was planned having been well met. One feature only gave trouble. This was for a time annoying and consisted in our inability to keep the shafts in line. These, 30 ft. in length and running at 1 800 r.p.m., were planned with what proved to be insufficient steady bearings, although, if run as at first contemplated, 900 r.p.m. or thereabouts, the writer does not think any trouble would have resulted. The addition of a complete new system of bearings and braces obviated this difficulty.

As finally determined, it was planned to construct the outfall sewer, from the pumping station above described, to a point in the outer harbor where deep water would be found and a route free from ledge obtained. The location of this outlet was to be determined at such a point that the currents should if possible under practically all conditions be such that no sewage should return to the shores.

As a preliminary to the investigation for these purposes, a careful survey was made of the entire harbor, triangulation stations established and all prominent features on shore located.

Floats of the usual types for surface and submerged work were prepared and set out at various points, and their tracks followed and plotted until all reasonable conditions of wind and tide had been investigated. In following these floats, a motor boat with an attendant to operate it was employed. In the boat, the man in charge of the survey work, with a recorder, followed the floats and at regular intervals located them by measuring angles to any prominent buildings, stations or other features on shore or to government buoys visible, all of which had been plotted previously. Angles were taken by a small quadrant, sometimes called a "dredging" quadrant, of the

type used by the Harbor and Land Commission, which for this purpose was found to be excellent. Numerous tests of its accuracy were made by locating the same points from two transit stations, the results invariably plotting within a very few feet of each other. After the results of these experiments had been studied, it was found that an outlet might safely be placed anywhere west of House Island and within about two thousand feet of it, and that, in such a location, little trouble need by anticipated from sewage returning to shore.

It now became necessary to take soundings to determine where to lay the line. It was planned to lay the pipe in a trench at the bottom of the harbor, so that it should be covered at least four feet, and naturally ledge was not desired. Soundings were therefore taken over a considerable area, which included all possible routes. By using grease upon the bottom of the lead, the nature of the bottom was quite readily determined, and by keeping tide-gage readings at fifteen-minute intervals, the depths below low water were closely obtained. After the results of these soundings had been plotted, the contour and extent of the ledgy bottom were drawn with considerable accuracy, and the fact appeared clear that the rocky islands of the harbor extended below water to a wide distance about them.

Upon this plan, routes were selected for an outfall, and borings arranged for. How to make these borings accurately and economically was a question which gave considerable concern. The writer was unable to find any literature on the subject or to get any very definite advice. What he wished to do was to obtain soundings to a depth of six feet below the bottom of the harbor and bay, to make sure that there was no ledge and to determine as far as possible the nature of the material. At first a lighter and tug boat were chartered, it being planned to sound from the lighter with one-inch pipe having a chisel end, guided and held in place by passing it through 3-in. pipe strapped to the side of the lighter. This outfit started in about fifty feet of water at low tide, at a point selected for the outlet, and worked toward shore. The arrangement outlined did not work very well, and, after we had carried away several lengths of pipe, was abandoned and soundings made with heavier pipe from a plat-

form on the side of the lighter. With this arrangement, some 2 000 ft. of borings were taken at about 50-ft. intervals, located from shore from two triangulation stations. The time of all borings was taken, and tide-gage readings carried on simultaneously. The results were slow, expensive and not as uniform as desired. The lighter was unwieldy, and in any sort of a ground swell accurate results could not be obtained.

We next chartered a large gasoline-driven launch. A hole was cut in her bottom, and a well constructed. Through this well, soundings were taken with a line of pipe as before, and very good results obtained with greater economy and accuracy than before. The deep water work was completed with this outfit. When a depth of not over ten feet of water at low tide was reached, soundings were taken at low tide directly from a rowboat, and the work completed. If the writer were to do this work again, he would be inclined to employ a small scow or lighter, erect a small tripod on it and sound from this, towing with a gasoline launch and working along with four anchors. He is very sure that he would be able to get just as accurate results and do it more quickly and cheaply.

With the borings obtained, covering the routes projected at about 50-ft. intervals, a route was selected which showed no ledge in the soundings nor on the bottom.

The soundings covered only the outer harbor, as no difficulty was anticipated in the inner harbor, which had been repeatedly dredged and found to be mud and clay. To reach the outer harbor from the inner harbor, it was at first planned to cross the inner harbor to the shore of the westerly side and run as far on land as possible before departing for the outlet. This we thought would be the cheaper although longer operation. Consultation with some who had had experience in these matters led us to ask for bids on alternate routes, all under water and nearly all below low tide.

Specifications were prepared calling for bids on this work, the town supplying the iron pipe at the town wharf in the village. There were two main provisions in the specifications; first, that the pipe should be laid with a cover of at least four feet in the bottom of the harbor; and, second, that it should, on

completion and before acceptance, successfully withstand a test of an internal pressure of 50 lbs. per sq. in. without perceptible leakage.

Bids were received as follows, the all-water route being called Route A; and the part land and part water, Route B.

	A.	B.
T. A. Scott Company	$56 800	$60 000
Wm. Gerrish	59 100	.....
W. B. Bryne	57 000	65 000
C. R. Gow Company	65 000	68 000
Merritt and Chapman	61 873	74 322

The bid of T. A. Scott Company for Route A was accepted, work commenced in June, 1914, and completed in January of 1915.

The first steps were the dredging of the trench for the entire route and the drilling of some ledges in a short section which was bare at low water. The outfall end was located from shore by two transits; and a float anchored to mark the point from which the dredger should work toward ranges on land but so far away that close watch from the survey stations was needed to keep the line straight. Further inshore, the work was easily controlled by ranges on shore and on the flats.

While the dredging was in progress, work was being carried on in constructing the outfall end in one mass, ready to lower in place at the proper time. It had been expected that it would be necessary to build a pile structure at the outfall end to which to tie the pipe, but after the dredging had been completed it was found to be ledge at a depth of about six feet below the bottom. A platform, 16 ft. square, was now constructed of 6 in. by 6 in. tongued and grooved stock, laid in two layers, at right angles to each other and solidly bolted together. Upon this platform was made up one length of 14-in. pipe and 3 $\frac{1}{16}$ bends upturned, the whole solidly secured to the platform. Around this was now cast a hemisphere of concrete having a diameter of about 8 ft. and weighing about 20 tons. (Fig. 1.) When completed, this was taken to the outlet and lowered in place, being leveled on the bottom by the divers and protected and brought to proper line and grade by building up with concrete in bags. At this

time, also, the upturned end was plugged with a 6-in. tapered plug of pine wood into which had been tightly fastened a 2-in. pipe and valve for future use in testing.

From the pipe thus laid, the line was laid toward shore, and meanwhile the dredgers moved in shore to dig other portions of the line.

FIG. 1. OUTLET STRUCTURE SHOWING CONCRETE BLOCK AND PLATFORM. UPTURNED OUTLET IS IMMEDIATELY BEHIND HAWSER.

The pipe was made up partly on shore and partly on the lighters, in sections of 6 lengths, regular bell and spigot joints being used. (Fig. 2.) After having been made up, the section was closed by special heads at each end and a pressure of 50 lbs. air applied, a soap solution applied to the joints and any leakage which might show cared for. The pipe thus made up was laid from the lighters by being first suspended from a steel truss by

chain slings under each joint brought to an even bearing by turnbuckles before hoisting, and a block of concrete 30 in. long by 15 in. wide and 6 in. thick, shaped to fit the pipe, suspended at each joint to form a bearing on the bottom. When all were fast, the truss and pipe were hoisted and the whole arrangement lowered to nearly the bottom of the trench. Here the spigot end of the pipe was guided into the hub already laid by the diver, a special device attached to bring home the ends of the pipe, and the other end of the pipe lined up by the engineer in charge, using, in deep water, ranges attached to the truss, and, in shallower water, the truss or the slings. After having been lined

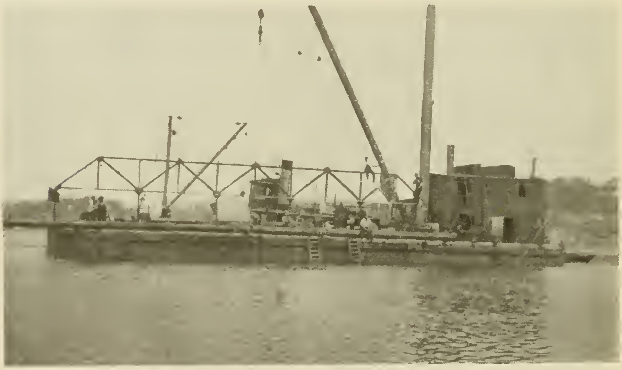

FIG. 2. CAST-IRON PIPE BEING JOINTED ON LIGHTER.

up, the pipe was laid to grade by soundings on the pipe, and when in proper position supports were built up under each joint with concrete blocks in addition to those attached at each joint, until a firm bearing was obtained. If excavation was necessary, as frequently happened, the material was pumped out, and if filling was needed, it was jetted in. In all cases, however, the concrete blocks were laid on firm, undisturbed bottom as a support for the pipe.

After several sections of pipe had been laid, and whenever the sea became too rough to lay pipe, the divers went down to

make up the joints between sections. These were made with Juto-lead wool and strips of cold lead cut to a length to make the circumference of the joint, and hammered home by compressed air tools and by ordinary hand hammer and chisel.

This general method was pursued throughout the work without special difficulty except that due to occasional rough weather. Pipes meeting from two opposite directions were joined with the ordinary sleeve. Sections where a vertical curve was desired were made up to conform to this curve laid out on the deck of the lighter from soundings by the engineer in charge.

After a considerable section had been laid, the ends were sealed and hydraulic pressure from the pump of one of the tug boats applied in an endeavor to obtain our requisite 50 lbs. This we were unable to do and, to discover the leak, applied air pressure. This indicated the leak very quickly, as the surface of the water was examined along the line, and after an examination the diver reported that one length of pipe was split for a distance of about three feet on its side. To remedy this we obtained a special split sleeve at considerable delay and expense, and secured it around the injured pipe, calking it as securely as possible with cold lead. This was tested and found to leak. The diver then tried to take up the bolts at the joints, and split the sleeve. We then did what we should have done in the first instance. That is, we broke out the defective pipe and by using an ordinary sleeve laid in a new section of pipe. After this had been made secure, we again applied hydraulic pressure to the pipe of 50 lbs. per sq. in., and after this had been held by the line for two hours with a drop of less than 3 lbs., it was felt that it was secure.

As a result of this experience, we thereafter, in testing our sections, sealed the ends, applied air as before, and then suspended the entire section over the side just under water. We found in this manner occasional defective joints but no more split pipe.

This general routine was followed throughout the work, no special joints being used at any point. The soundings proved reliable, less than 20 yds. of ledge being found along the under-

water trench. The greatest delay and most difficult work proved to be due to the short section where the line, to avoid the channel of the outer harbor, passed over a point of rocks and ledge between high and low water. Here the men from the lighters, who were splendid workers on water, somehow or other seemed lost on land, and the bulk of the excavation was performed by the laborers supplied by A. G. Tomasello, the contractor on the street work. The ledge, too, was quite seamy, and both steam and air drills were used, the latter with great effectiveness.

At two points along the outfall sewer are constructed blow-offs, one near the pumping station and one at the rocky point just described. These are for emergency use only.

The pipe was tested in short sections as laid, leaks being discovered as before described, and at completion the entire line was tested and the required pressure maintained successfully.

The entire length of the outfall as finally laid is 8 657 ft., and the cost, exclusive of engineering, was a trifle over $68 000. The entire system — including the street mains, pumping station and well, and the outfall — was constructed within the appropriation made, except for land damage, and cost approximately $220 000.

Mr. Charles A. Fritz, of this Society, was in charge of the outfall work, and I am indebted to him for much of the detail of this paper.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

EXTENSION OF THE NORTH METROPOLITAN SEWERAGE SYSTEM OUTFALL AT DEER ISLAND, BOSTON HARBOR.

By Clarence A. Moore.*

(Presented before the Sanitary Section, January 3, 1917.)

I appear before you through the courtesy of your Society and of Mr. F. D. Smith, chief engineer of the Metropolitan Sewerage Works, to endeavor to give you an idea of the extension work now in progress at the outfall of the North Metropolitan Sewerage System at Deer Island, Boston Harbor.

For the benefit of any who may not be familiar with the sewerage systems of the Metropolitan District, I will state briefly that this area is divided into three distinct sewerage districts: namely, the South Metropolitan district, serving the territory in general south of the Charles River; the North Metropolitan District, serving the territory north of the Charles River; and the Boston Main Drainage District, lying between the two already named.

Of these systems, we are concerned this evening with only that serving the North Metropolitan District, which includes the municipalities of Winthrop, East Boston, Chelsea, Everett, Malden, Melrose, Charlestown, Cambridge, Somerville, Medford,

Note. Discussion of this paper is invited, to be received by W. L. Butcher, editor, 14 Beacon Street, Boston, before May 10, 1917, for publication in a subsequent number of the Journal.

* Assistant Engineer, Mass. Metropolitan Water and Sewerage Board, Boston, Mass.

Winchester, Woburn, Stoneham, Arlington, Belmont, Wakefield, a part of Lexington, Revere and Reading. The last-named town has been admitted but recently to this district, and the trunk sewer has not yet been extended to this town.

The sewage from this district, comprising the seventeen municipalities and the two d stricts of the City of Boston named and Deer Island, with an area of approximately 100.35 square miles and an estimated population of 621 700, 's discharged through the Deer Island Outfall into Boston Harbor at a point about two hundred feet west of Deer Island Light. (Fig. 1.)

This outfall is on the southerly slope of Deer Island Bar, about 1 900 ft. from the Deer Island mainland and about 3 500 ft. from the Deer Island pumping station, where the sewage is lifted to an elevation sufficient to discharge it continuously against the varying tidal head. The outlet is one-half foot below mean low water; and discharges vertically; while the general direction of flow is toward the main ship channel, where strong currents tend to dissipate the sewage rapidly.

The existing outfall was placed at a t'me when such method of sewage disposal was practically untried, on a large scale, but has proven successful in so far as pollution of the shores is concerned. There has always been discoloration of the water in the ship channel for some distance, perhaps one-half mile, about the outfall. The outfalls of the South Metropolitan System, placed about nine years after that at Deer Island, are thirty feet below low water. The condition of the harbor water has been so much better around the outfalls of the South Metropolitan System than around other outfalls, that the Massachusetts Metropolitan Water and Sewerage Board is now seeking to improve the North Metropolitan System outfall by a similar submergence, with the added improvement of multiple outlets.

Complaints about the condition of the water surrounding the Deer Island outfall have been made by boating interests; and by officials of the United States government in view of the proposed use of the south end of Deer Island for military purposes, and because of the proximity of the Deer Island lighthouse, a structure not in existence when the outfall was designed.

The improvement of the Deer Island outfall, mentioned

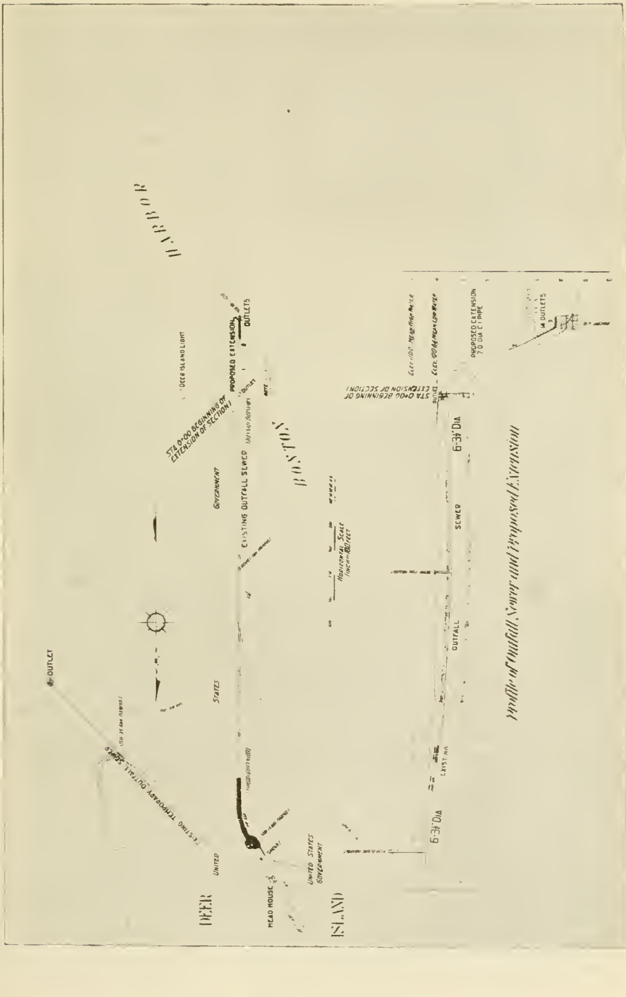

FIG. 1. EXISTING, TEMPORARY AND PROPOSED SEWER OUTFALLS AT DEER ISLAND.

above, involves an extension of the existing sewer some 315 ft. (See Fig. 1.) To this extension the present paper is devoted.

For the first step, a temporary outlet had to be provided, so that the sewage flow might be diverted during the construction of the extension of the permanent outfall. This temporary line (see Fig. 1) was started at a point on the existing outfall sewer, about 200 ft. back from the high-water line on Deer Island. Here a double chambered stop-plank manhole was built, the chambers extending to the bottom of the old sewer, and a new branch was cut into it at an angle of 30 degrees.

From this manhole a 6 ft. 6 in. circular sewer of reinforced concrete was built, following in a general way the southerly shore-line of the island for a distance of 770+ ft. From a second manhole, located where this 6 ft. 6 ins. sewer ends, four hundred feet of 60-in. cast-iron pipe was laid partly in open, hand-excavated trench and partly in dredged trench. A 90-degree bend forms the outlet of this line, the opening being upward and some three feet below mean low water. This line was studied and designed with the expectation that it would at some time be extended to a point where the water is forty-five feet deep. With this provision of two outlets, the advantage of distributing the sewage over a considerably larger area will be gained.

Dredging was commenced July 9, in preparation for the extension of the old line. As no dipper dredge which could work to the required depth was available, the work was accomplished with orange-peel and clam-shell buckets. The material removed was almost entirely coarse gravel, although a little blue clay was encountered near lowest depth reached. Dredging was continued along the center line of the trench, no particular attention being given to the side slopes until sufficient depth was obtained.

An area 64 ft. by 20 ft. was dredged to about 58 ft. below low water, the outer end of this area being about 322 ft. south of the old outfall. From this area, the trench extended back to the existing outlet, the depth being such that reëstablishment of the original surface conditions after the pipe is in place will leave the pipe slightly covered to a point on the pipe a little north of the first outlet opening. From this point to the outer

end, the grade of the pipe brings it gradually above the sloping ground. The water-line at the extreme end is about fifty-four feet below low water. (Fig. 2.)

In the sloping trench for a distance of 54 ft. from the level area described, single stones 6 ft. to $7\frac{1}{2}$ ft. long by $4\frac{1}{2}$ ft. wide by 2 ft. thick were laid firmly on the gravel bed of the trench as a foundation for each pipe. Two concrete sills 8 ins. by 12 ins. by 6 ft. were set upon each of these stones to adjust the pipe to required grade.

From this point to the old outfall, pile bents, of two piles each, spaced 6 ft. 0 ins. on centers, will be used as the work progresses. These bents will be 4 ft. 6 ins. apart and will be capped with 10-in. by 10-in. yellow pine timber. The change to pile foundation is due to the fact that the dredged trench becomes hardly more than a level bench on the side of the slope. It is considered that piles will afford a more secure support against lateral sliding.

Over the level area at the south end, mentioned above, a layer of granite chips was placed between Stas. 2+58 and 3+22 to even up irregularities left in dredging. On this bed, granite blocks 2 ft. in thickness were placed. Most of these blocks are from 12 to 15 ft. long by 4 ft. 6 ins. to 5 ft. 0 ins. wide. Some few are more nearly square, measuring about 9 by 7 ft. by 2 ft. thick.

On this foundation course, a second course of dimension granite blocks 2 ft. thick was placed. The stones in this course are so laid that the outer ends of adjacent stones are nea · opposite sides of the lower course, and the inner ends overlap under the pipe, forming a continuous layer. In this way spaces were left on either side of the pipe between alternate stones into which buttress stones 6 ft. 0 ins. by 5 ft. 6 ins. by 4 ft. 0 ins. were fitted. These buttress stones, placed against the pipe just back of the bells, secure the pipe against any lateral or longitudinal movement. The three outer buttress stones on the east side of the pipe location were set before the pipe was placed.

The 84-in. pipe, with specials, was furnished under contract by the United States Cast-Iron Pipe and Foundry Company, of Burlington, N. J. They were brought to South Boston by rail, lightered to the Deer Island shore, and landed on the beach

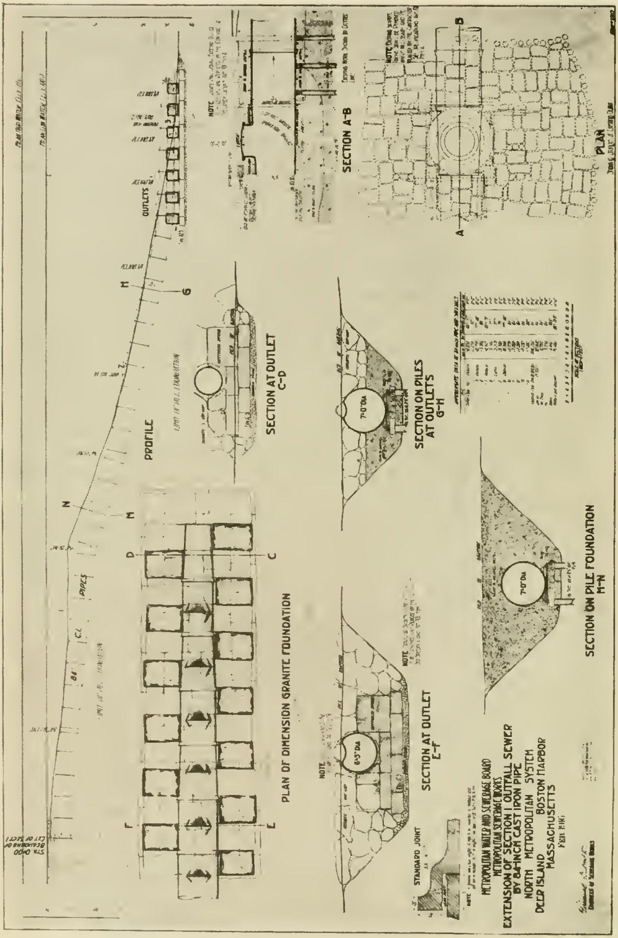

Fig. 2. Proposed Sewer Outfall at Deer Island.

at high water. (Fig. 3.) The pipes, which are in 9-ft. lengths, are 2 ins. thick and have bells 6 ins. deep. The standard pipes weigh about 17 000 lbs. each. The heaviest piece, a reducing tee 75 ins. by 84 ins. by 75 ins. and 11 ft. long, which is to make the connection with the existing structure, weighs 24 980 lbs. Twenty-three of these pipes, including all those having outlet openings, were coated externally with "Bitumastic" enamel while on the Deer Island shore. The object of this treatment is to protect the more directly exposed pipe from the action of salt water.

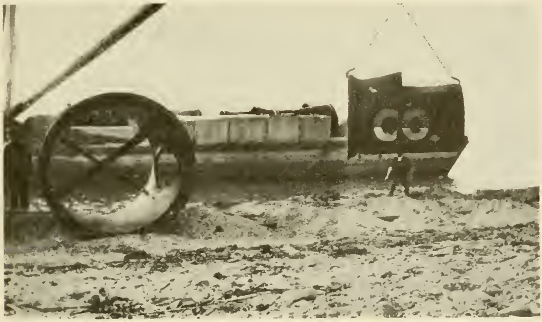

Fig. 3. 84-in. Pipe Landed on the Beach at Deer Island.

To lay the pipes, six at a time were taken aboard the lighter of the contractor, Roy H. Beattie, Inc., and made together on blocking into three-pipe sections, the joints being leaded. These sections were handled by being slung from a strongback in straps of wire rope by the derrick boom of the lighter.

In placing the sections, the lighter was secured to permanently established mooring lines and drawn into position above the prepared foundation. The pipe was then lowered on to the concrete sills placed by the divers, adjusted to required grade, and securely blocked. The outermost two sections were placed in this manner on the heavy stone foundation, and the remaining buttress stones were set in position.

The third section, consisting of two straight pipes and a curve, as may be seen from the profile (Fig. 2), extends beyond the heavy stone foundation described and is laid with considerable slope, about 1 to $4\frac{1}{2}$. It is obvious that, to lay the pipe on this slope without danger of displacing the sills, the pipe must be lowered in a sloping position so that the spigot end can be inserted in the bell of the previously laid pipe before the other end comes to a bearing. To accomplish this, the contractor provided a special strongback formed of two 15-in. channels riveted together, with separators between. Three hanger plates are riveted to the sides of each channel, and to these hangers are attached straps of wire rope. (Fig 4.) In slinging the pipe, the free end of these straps is hooked into the eye of a turnbuckle suspended from the hanger at the other side of the strongback. This affords a very convenient method of tightening the straps.

Near either end of the strongback is a pin 3 ins. in diameter, around which is passed an endless, heavy wire cable. The two strands of this cable pass through a yoke, the position of which can be adjusted before the apparatus is brought under tension. Under tension, the yoke is clamped rigidly in position. By trial, the position of this yoke is so established as to give the required slope to the pipe, and the suspended section is then lowered to place.

The joints between the sections were calked by the divers with lead wool with ordinary calking tools. A strip of lead cast 6 ins. wide by $\frac{1}{2}$ in. thick, and of sufficient length to extend around about one third the perimeter of the pipe, was placed in the lower part of the bell of each slip joint. This served to keep the spigot end up in alignment and to reduce the amount of calking required at the most difficult part to reach. In addition to the lead so placed, each joint required about 150 lbs. of lead wool, and consumed about two days' time for completing the calking. One diver would usually be calking joints while the other was at work preparing the foundation to receive another section. During the period of strongest tidal current, when material could not be lowered, both divers worked on the joints.

Owing to the very exposed location of this work, there was

necessarily much lost time. The unusually stormy spring and summer, with much foggy weather, was especially unfavorable, and work other than dredging was not started until about September 20. The swift currents and frequent heavy undertow encountered in this location rendered the placing of material other than rough stone for riprap work impossible except at slack water on days when there was no considerable undertow.

When it became necessary to suspend work on account of weather conditions, four sections of pipe (108 ft.) had been placed. Two of these sections were laid on the heavy

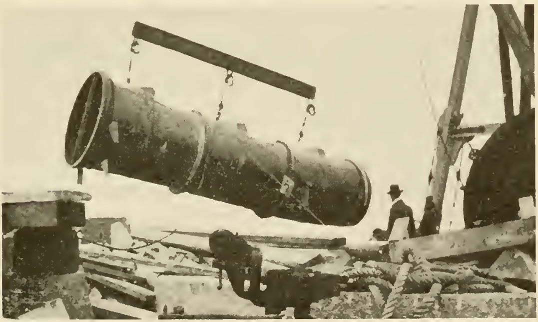

Fig. 4. Method of Laying Pipe on a Slope.

stone foundation with but little slope, and the other two were laid on the incline. Blocks of broken granite and granite chips have been placed under and around these pipes and between the buttress stones, forming a defense extending about twenty feet on either side of the center line and rising to the general grade of the top of pipe. No backfilling has been done about that portion of the line where the fourteen outlets are located with any fine material which might be washed from place. The inshore end of the pipe and the three outlet openings in the section last laid are bulkheaded, to prevent filling with gravel during the winter.

When work is resumed in the spring of 1917, the pipe laying

will continue toward the existing outlet on a pile bent foundation to the point where the sleeve is shown. (See Fig. 2.) The existing outfall will be broken out and the reducer tee 75 ins. by 84 ins. by 75 ins. will be connected into the existing channel. The branch will be capped and the pipe will be extended to meet the pipe laid from the outer end. The closure will be made with a sleeve as indicated on the drawing, two pipes having both ends spigots being utilized for this purpose.

The discharge under the new conditions will be from fourteen outlet openings, increasing in size toward the outer end. The diameters of these openings, which are approximately elliptical, with the exception of the outermost, which is a 48-in. circle, vary from 25 and 44 ins. to 13 and 23 ins. respectively. The reduction from 84 ins. to the 48-in. terminal outlet is accomplished in seventy-two feet by making alternate pipe into reducers, the reduction in each being nine inches.

The design of the pipe was determined as the result of studies for different conditions of tidal head and flow. The areas of the several openings are proportioned so as to discharge as nearly equal quantities as possible.

While the sewage will inevitably come to the surface, due to the difference between its specific gravity and that of sea water, it is confidently expected that the greater opportunity for dissipation and dilution before the surface is reached, with this scheme of distributed discharge under a considerable depth of water, will result in materially improved appearance of the water about this portion of the harbor.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

DISCUSSION OF "EFFECT OF CHANNEL ON STREAM FLOW."

By C. H. Pierce, Dwight Porter, D. M. Wood, R. A. Hale, H. K. Barrows and N. C. Grover.

Mr. Pierce.* — There is one phenomenon very closely related to the subject of Mr. Grover's paper which I believe has not been fully covered, and that is the effect of ice in destroying the stage-discharge relation which exists during the open-water period. A rating curve may be defined by a series of discharge measurements having a high degree of accuracy, but as soon as ice forms to any appreciable extent the channel conditions are changed and the rating curve is no longer applicable. In a section of the country where ice may exist from November to April, the minimum flow for the year possibly occurring during this period, the collection of winter records becomes a problem in itself. As in many other problems of hydraulics, the solution has been found by experiment and experience, rather than from theoretical deduction.

It may readily be seen that the amount of backwater at the gage, that is, the increase in gage reading over what it would be under normal conditions, does not remain the same throughout the winter, but varies with the nature of the ice formation. In general, the backwater begins with the formation of shore ice or by ice freezing on exposed rocks at the control, although

* District Engineer, United States Geological Survey, Boston.

in some cases "anchor" ice and slush ice may be the first disturbing feature. There is often a sudden rise succeeded by a fall, after which the backwater gradually increases as the stream becomes covered with ice and as the ice increases in thickness. This may be explained by a decreased area in effective cross-section of the channel and by the formation of ice on the control. If the ice remains in place throughout the winter, with no break-up or ice jam, it is possible with a few discharge measurements and a careful study of temperature and precipitation records to make a correction for the backwater and secure what may be called "effective gage heights," to which the open-water rating curve is applicable. This correction is best made graphically (Fig. 1) by plotting the results of discharge measurements and obtaining a backwater curve which is subtracted from the observed gage height graph to secure the effective gage height graph. In determining the backwater curve, the thermograph or temperature record and the precipitation are carefully studied to see that the results are consistent.

If the ice conditions do not remain stable throughout the winter, but are interrupted by break-ups and ice gorges, the work of making winter estimates becomes more complicated and a larger number of discharge measurements are needed.

One point should be emphasized in connection with this feature of the work, and that is, the selection of the site for the gage. If a site is selected with reference to its adaptability for winter work it may be possible to secure better results at less expense than would otherwise be the case.

A very full discussion of the effect of ice on stream flow may be found in Water-Supply Paper 337.

Professor Porter.* — I should like to ask how near above the artificial control the gaging station is usually placed. I thought it appeared to be but very little above in two or three of the lantern views.

Mr. Grover. — In many cases, yes. In streams that carry a great deal of débris it is practically necessary to put the artificial control very close to the gage, otherwise the bars of sand and gravel and other drift will cause a secondary shifting

* Professor of Hydraulic Engineering, Mass. Inst. of Technology.

control to be built between the gage and the control, so that the value of the control is lost.

PROFESSOR PORTER. — For many years and until rather recently, the civil engineering students at the Massachusetts Institute of Technology were given practice work with the rod

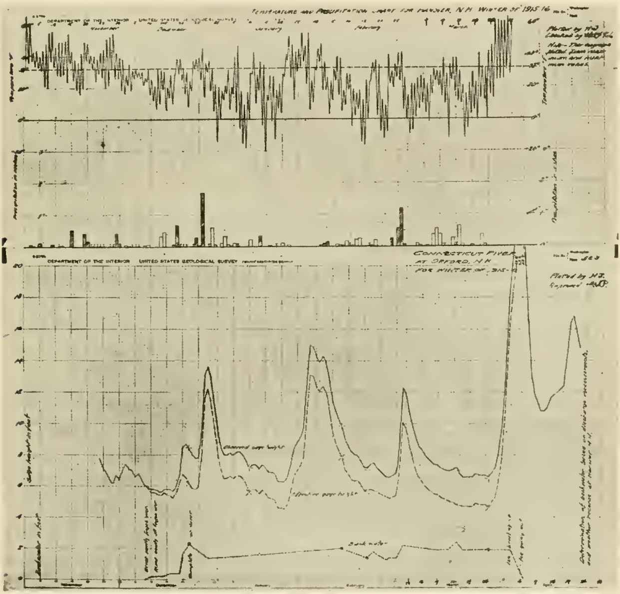

FIG. 1. GRAPHICAL METHOD OF DETERMINING BACKWATER FROM ICE.

type of current meter on the Charles River at Newton Upper Falls, and afterwards on Mother Brook at Dedham. Being interested to see how the gagings of a series of years would show up on a station rating curve, I had them plotted for the Charles River at Newton Upper Falls, but the points proved much too scattered to give a definite curve. The first thought was that this might be due to errors in the work of the students, as they

were all beginners. Nevertheless, the conditions were favorable for good work and the gagings were closely supervised, and I later suspected that the difficulty was not so much due to unskilled work by the students as to obstruction of the stream at and below the point of measurement by a thick growth of aquatic plants, which Mr. Grover has mentioned as sometimes a disturbing cause. There was such a growth here, which very likely varied from year to year and which was sometimes cut away for the purpose of removing the obstruction to the flow of the stream. That the irregularity shown by the plotted points was probably not due to faulty work by the students, was indicated by the fact that for the Mother Brook gagings, carried on in precisely the same way as those on the Charles, a very smooth station rating curve was found.

Mr. Wood.* — The Geological Survey engineers are pioneers in the technical development of the theories and methods of stream gaging in this country, and it is difficult for others not engaged constantly in such work to suggest new points of view. In the paper under discussion, a summary of many fundamentals evolved from field studies covering many years has been concisely and clearly presented.

The title of the paper might possibly be amended by the addition of the word "Measurement" or "Determination," since Mr. Grover's argument is devoted to the effect of natural or artificial conditions upon the accuracy of the determination of the amount of water flowing past a given gaging section.

It would appear that Mr. Grover's remarks might logically be grouped under two headings: (1) the effect of channel at or near the gaging section; and (2) the effect of the "point of control." It is very surprising to learn how much the second overshadows the first in importance.

Nevertheless, the conditions *at* the gaging section will usually influence to a great extent the selection of the site. Some of the factors to be considered may be listed as follows:

(A) *Channel Conditions.*
1. Permanence of the section.
2. Roughness of the section.

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* With Stone & Webster Engineering Corporation, Boston.

3. Character of the current, — i. e., measurable range in velocity from 0.5 to 15 ± ft. per second, no serious eddies, lines of flow at right angles to the measuring section, etc.
4. Free gravity flow, — i. e., no erratic back water from tributary streams below or from dams, aquatic plant growths, ice or log jams.
5. The possibility of securing a suitable location for the gage.

(B) *Desirability Conditions.*

1. Accessibility.
2. Availability of structures for gaging purposes.
3. Reliability and cost of gage reader.
4. Possible regulation of water at points upstream; also possible diversions.
5. Annual operating costs.
6. Desirability and need of gagings.

The accuracy of the determination of the rate of discharge is dependent upon both the accuracy of the gage readings and the accuracy of the current meter measurements. The first depends upon the conditions described so well in the paper, but the last is dependent more upon the conditions at and above the measuring section than below it.

The extreme range from minimum to maximum of both stage and discharge is so great for the majority of our streams in this neighborhood that it is difficult to construct a gage that will give the desired accuracy except for a portion of the range.

The current meter itself will give nearly perfect accuracy under conditions of absolutely uniform flow, but, as Mr. Grover briefly stated, when the flow is at all irregular in direction with reference to the gaging section, some types of meters will over-register while others will under-register. In cases of non-uniform flow, no meter yet developed will accurately measure the rate of discharge under all conditions. The small Price meter, as improved by the Geological Survey, is the best adapted to general stream gaging work, but it is a question whether or not it should be held rigidly in a horizontal plane.

In the average stream, especially in this locality, the river channel at and above the measuring section is more or less rough. A bowlder located some distance upstream will often introduce irregularities of flow at the section.

The point of control itself, unless artificial, is not likely to

be absolutely uniform across the entire channel, and this may, and often does, introduce irregularities of flow at the section.

It would, therefore, appear that the question of effect of channel on the accurate determination of discharge is connected intimately with the development of an accurately reading gage and a type of meter that will register correctly under all conditions of flow. Some of the factors, of importance now, will of course become of less importance if an accurately recording meter is developed.

Certain studies, not as yet made public, would indicate that such an ideal meter may sooner or later be found. Indications are that it will be of the horizontal or propeller type.

Now that the question of channel conditions has been so thoroughly studied, it would seem that the next step would logically consist of further experimental work on the behavior of different types of meters under angular velocity conditions, as a step toward the perfection of the meter.

About two years ago, the writer had charge of the hydraulic measurements in some turbine tests where the angular velocity conditions were in some cases very marked. He experimented with three types of meters, five meters in all. Three were small Price meters, one of which was wired to prevent tipping in a vertical plane. All meters were interchanged throughout the tests and comparisons indicated that one type over-registered as much as 10 per cent. in some cases, while another type under-registered 2 or 3 per cent. The small Price meter, which was wired to prevent tipping, apparently gave the most accurate and consistent results, although unfortunately they were not conclusive because of the usual lack of time and appropriations for the work.

Mr. Hale.* — Regarding the Merrimack River at Lawrence, Mass., there is a gage in the river about a mile below the dam, known as the Lower Locks gage, which serves as an excellent index for a rating curve of discharge. There are no dams between this gage and the mouth of the river at Newburyport. About six miles below the gage, Mitchells Falls is situated, the upper end of which acts as a controlling point in the flow. The

* Prin. Asst. Engineer, Essex Water Power Co., Lawrence, Mass.

tides flow part way up on the falls and there is a free discharge to the mouth of the river. In the various stages of heights of river the surface slopes are nearly parallel, showing that the increased cross-sections practically provide for the increased quantities, and a fair rating curve is obtained.

There are some differences noted in the comparison of gage heights and quantities of water flowing, depending on whether the river is rising or falling, due probably to changes in the sections, but these differences are small. During the winter, with ice covering the surface, the water stands one or two feet higher at the gage than with the corresponding quantities in the summer time, and corresponding corrections must be made in the rating curve.

The quantities are usually determined from the flow over the dam and the quantity drawn by the mills for the most of the year, and the rating curve is used but a very small part of the time and some years not at all. The daily variation in the quantities flowing is considerable. During the working hours of the day about 5 000 sec.-ft. is drawn by the mills, and at other times about 2 000 sec.-ft. is drawn by the mills for electric lighting and by such mills as require water for twenty-four hours.

I consider it of great importance to have a first-class recording gage at the rating stations of the various rivers, in order to determine the flow throughout the twenty-four hours. When one gage reading is taken during the day, the flow at that time is ascertained, but no knowledge is had of its relation to other periods of the twenty-four hours. With various dams located on a river using water for ten and twenty-four hours power, variations in river heights exist that make it essential to have continuous readings. In the natural flow of a stream this difference may not be so marked, but it is important to know this relation which exists.

Mr. Grover. — We are all looking for a good pressure gage, that is, a pressure gage that is dependable. The great advantage of the pressure gage is obvious in the decreased cost and the ease and speed of installation, and if a pressure gage can be developed that will give sufficiently accurate results for a portion of the work even, it will be of great value. Many

stations are maintained where approximate records are all that could be expected or desired, and it is believed that the field for a good pressure gage would be quite extensive, not only in the special work that Professor Sanborn first took up in the design of his gage, but in general stream gaging.

Mr. Hale. — I would say that at Lawrence we have been using a pressure gage for over a year and we have had very good success with it. The scale is rather large, and it can be read to within one or two hundredths of a foot and agrees very closely with the scale set in the canal for comparison, and it has given very good satisfaction. We have placed a kerosene lamp in extremely cold weather in the box where the recording instrument is located, and the diaphragm has thus been kept free from ice and has given satisfactory results during the cold weather.

Professor Barrows.* — Mr. Grover's paper has brought out clearly the fact that the "control method" of measuring streams, carried on by the Geological Survey, is similar in principle to that of using a weir. The artificial control in the stream is comparable to the weir, and as no weir formula will give the discharge accurately it is measured with a current meter at different heights and the "weir" rated. When the quantity of water flowing is so small that it becomes difficult to make an accurate measurement with the current meter, the construction of a standard weir, for which a definite discharge formula is known, may become preferable. A stream of small discharge is very easily affected by temporary obstructions, such as floating leaves or ice, and may require many current meter measurements and such close supervision that the cost will exceed that of weir measurements. On the other hand, in connection with other investigations, surveys, etc., in the vicinity of the gaging station, it may be possible to get the record of flow more economically by the current meter method than by constructing a weir.

Perhaps it is not out of place at this time to speak of the work which the Geological Survey is carrying on and the extent to which the states are coöperating with the national government. Many are probably not aware that the national appropriation for this work is very small, and in many cases it is only

* Associate Professor of Hydraulic Engineering, Mass. Inst. of Technology.

possible to accomplish substantial results by coöperating with the states.

The state of Massachusetts has been contributing to this work of stream gagings for the past five years, to the extent of three thousand dollars per year. A tangible result of this coöperation is a report upon "Surface Waters of Massachusetts" (Water Supply Paper No. 415), recently issued by the U. S. Geological Survey, which contains much new and valuable information in regard to the water supply of the state.

One who has occasion to make use of stream flow data is struck at once by the dearth of specific information along these lines. In the eastern part of the state, for instance, one finds the long and accurate record kept on the Merrimack at Lawrence, which data are, however, for a large stream and not usually well applicable to questions of water supply on smaller streams. The records of the Metropolitan Water Board on the Sudbury and Nashua rivers, while carefully kept, are on streams in both cases with large reservoirs and consequent large proportion of water surface, where the results are practically good only for use in periods of a month at a time, owing to the large corrections necessary for storage. Obviously, such records are of no service in considering flow by days, and as a matter of fact there are few records of any great length of time in this part of the state which are of use in predicting the water supply of small streams.

Water Supply Paper No. 415 is an excellent beginning, however, and it is to be hoped that the state and the U. S. Geological Survey will continue steadily on this valuable work and extend its scope if possible. Every opportunity should be utilized by engineers to commend to Congress and to the state legislature the value of these investigations.

MEMOIRS OF DECEASED MEMBERS.

THOMAS FRANKLIN RICHARDSON.*

DIED DECEMBER 26, 1915.

THOMAS FRANKLIN RICHARDSON was born in Woburn, Mass., on February 10, 1855. Mr. Richardson was descended in the eighth generation from Samuel Richardson who came to this country from the south of England, about the year 1630, with two brothers, Ezekiel and Thomas. Samuel Richardson and his wife became members of the church in Charlestown which subsequently became the First Church of Boston. Some two years after, a distinct church was organized in Charlestown which became the First Church in that place. In 1640, the three Richardson brothers, with four others, organized a new church in what was then the limits of Charlestown but was established as the separate town of Woburn. The original town of Woburn included much of what is now Winchester, some of Wilmington and a portion of Stoneham. The Samuel Richardson home was located within the present limits of Winchester. The second house built on this site nearly two hundred and fifty years ago remained practically in its original condition until a year or two ago, when it was destroyed by fire.

Mr. Richardson graduated from the Boston English High School in 1872.

Mr. Richardson commenced his engineering work in May, 1873, as rodman on the investigation and construction of the aqueduct, sixteen miles long, built mainly of brick and rubble masonry, having a capacity of 110 000 000 gals. per day, of the Sudbury Water Works for the city of Boston. At the close of this work in May, 1878, he held the position of instrumentman on a construction party.

From November, 1878, to October, 1879, he was assistant

* Memoir prepared by Hiram Allen Miller.

engineer for the city of Chelsea, Mass., engaged in general city work, particularly having charge of the construction of a brick trunk sewer.

In November, 1879, he entered the engineering corps of the Atlantic & Pacific Railroad (now part of the Santa Fé system). He was first topographer on the surveys for the location of the line and subsequently had charge of some twenty-five miles of railway construction, partly in New Mexico and partly in Arizona, as superintendent as well as engineer. This work included two bridges, the Padre Canon and the Canon Diablo. The Canon Diablo Bridge was a notable piece of construction for that time, being a steel trestle having the extreme height of some 225 ft. and a length of 600 ft. All this work was very difficult, labor conditions being unusually bad, and it was necessary to haul water for construction purposes for a distance of twenty-five to thirty miles, largely by teams. His connection with this road ceased in June, 1882.

In September, 1882, he entered the engineering corps of the Mexican Central Railway, remaining with this company until July, 1885. His work included the construction of the Encarnacion Bridge, 175 ft. high and 1 300 ft. long, situated some three hundred miles north of the City of Mexico. This bridge was larger than any other bridge that had been constructed in Mexico at that time. Mr. Richardson designed the masonry for the abutments and pedestals, and superintended the erection of the iron work, which was done mainly by Mexican laborers, it being necessary to educate these laborers to drive rivets and do similar work. For about a year he was bridge engineer on the southern half of this railroad, and for a year was resident engineer on the northern six hundred miles of the railroad, designing and laying out the masonry for a large number of bridges.

From September, 1885, to June, 1886, Mr. Richardson was division engineer on the construction of the Chicago, Burlington & Northern Railroad in Wisconsin, having charge of the timber trestle work across the Wisconsin River and some heavy grading work.

From July, 1886, to April, 1887, he had charge of railroad surveys, designs of structures, and estimates in the mountains

between Glenwood Springs and Aspen, Colo., for the Colorado Fuel Company in the development of their coal properties. Here he located a number of railroad lines with grades as high as five per cent., using switchbacks on several of the lines.

From May, 1887, to December, 1888, he was division engineer on the construction of the Atchison, Topeka & Santa Fé Railroad, in charge of the division yard at Chillicothe and the heavy work near the Illinois River, and for most of the last year was resident engineer in charge of all new work in the state of Illinois.

From January to April, 1889, he was engaged on location work for the Denver & Rio Grande Railroad, locating a line in the San Luis valley from Villa Grove to Alamosa.

Between April, 1889, and January, 1892, he was chief engineer of the construction and location of the Manitou and Pike's Peak Railroad, designing all the structures and working out the necessary appliances for laying the rack rail. The maximum grade of this railroad is 25 ft. per hundred, maximum curvature 16 degrees. The Abt rack rail was used. This railroad is 9 miles long and extends from an elevation of some 6 000 ft. to an elevation of 14 100 ft. above sea level. About $3\frac{1}{2}$ miles of this road are above the timber line.

From February, 1892, to March, 1893, he was with the Sanitary District of Chicago as assistant engineer, having charge of the construction of several miles of the Lemont portion of the main channel, 160 ft. wide and something over 30 ft. deep.

From April to August, 1893, he was engineer in charge of the Sixty-Eighth Street tunnel for the city of Chicago. This is one of the water tunnels of the city of Chicago extending four miles under Lake Michigan. It was built of brick through clay and silt, and quite difficult of construction; on a large portion of it compressed air was used.

In August, 1893, he returned to Massachusetts, and from that time until June, 1895, had charge of all the surveys for reservoirs and aqueducts for the State Board of Health, in connection with the investigations for a water supply for the Metropolitan District, and made preliminary designs, locations and estimates of cost. The work included the location of the Wachu-

sett aqueduct, 12 miles long, having a capacity of 300 000 000 gals. per day; the Wachusett reservoir, having a capacity of 65 000 000 000 gals.; the Wachusett dam and different structures connected with the same; the location of a reservoir on the Ware River, capacity of 11 190 000 000 gals., and a tunnel 8.7 miles long connecting this reservoir with the Wachusett reservoir; the location of a reservoir on the Swift River, having a capacity of 406 000 000 000 gals., and of a tunnel 27.6 miles long, connecting this reservoir with the Wachusett reservoir; and the location of the Weston aqueduct, length about 13½ miles, capacity 300 000 000 gals. per day. He also made a study of other sources of supply.

From July, 1895, to January, 1906, he was engineer of the Dam and Aqueduct Department of the Metropolitan Water Works, in charge of the construction of the Wachusett aqueduct, 12 miles long, built largely of concrete, including one tunnel 2 miles long, and a masonry arch bridge some 400 ft. long over the valley of the Assabet River. In this connection he had charge of the sewage treatment plant for taking care of the sewage of the town of Clinton, including a power station for pumping the sewage and about 25 acres of filter beds. He also had charge until May, 1896, of studies for the location and design of the North Dike, and of the land surveys for the Wachusett reservoir. His work included the relocation of the Central Massachusetts Railroad from Berlin Junction, where it passes over the New York, New Haven & Hartford Railroad, to the North Dike, including a steel viaduct about 1 000 ft. long and 135 ft. high across the Nashua River below the dam. He made the final location of the Weston aqueduct, on which are one tunnel, 1 mile long, and two tunnels, each about ½ mile long, two shorter tunnels and also nearly a mile of steel siphon pipes 90 ins. in diameter. He was in charge of the investigations for the Wachusett Dam and all construction work connected with it, including a large amount of excavation at the site of the dam, which was done by day laborers. Mr. Richardson was also engineer of the Reservoir Department in 1905.

From January to March, 1906, Mr. Richardson was construction superintendent for the J. G. White Company, Inc.,

in charge of the Laguna Dam near Yuma, Ariz., for the Reclamation Service of the United States.

From March to July, 1906, he was again connected with the Metropolitan Water Works as engineer of the Dam and Reservoir Department.

From July, 1906, to July, 1907, he was resident manager in charge of the construction of the plant of the Rockingham Power Company on the Peedee River, at Hamlet, N. C.

In September, 1907, Mr. Richardson was again associated with the J. G. White Company, Inc., and placed in charge of the La Crosse water power development at Hatfield, Wis., returning to New York late in December of the same year. On January 1, 1908, he was appointed general superintendent of construction, in general charge of contract work for the New York office. As general superintendent he had charge of hydro-electric work as follows: La Crosse Water Power Company's development at Hatfield, Wis.; Connecticut River Power Company's development near Brattleboro, Vt.; the Central Georgia Power Company's development at Jackson, Ga.; the Idaho-Oregon Light & Power Company's development at Copperfield, Ore.; and the Minnesota-Ontario Power Company's development at International Falls, Minn.; and also the Idaho Irrigation development in the vicinity of Richfield, Ida.

These hydro-electric developments were all approximately 20 000 h.p. in size, and the irrigation proposition covered 150 000 acres. He held this position until September 1, 1909, when he was made chief civil engineer of the company. In this position he made numerous investigations, studies and estimates for power developments, etc., and was used by the J. G. White Company, Inc., as consulting expert on engineering matters. While in this position Mr. Richardson acted as consulting engineer in connection with the Fellsmere Farms Company's work of reclaiming 115 000 acres of land in Florida.

Mr. Richardson held this position until the engineering department of the J. G. White Company, Inc., was taken over by its subsidiary, The J. G. White Engineering Corporation, January 1, 1913, at which time Mr. Richardson automatically became civil engineer of The J. G. White Engineering Corpora-

tion. He held this position and was occupied on reporting and consulting duties until August 1, 1914, when he resigned on account of failing health. He was, however, able to do some consulting work after that date.

For over forty years he was continuously engaged on engineering work, and acquired a valuable experience on the construction of railroads, water works, hydro-electric plants and irrigation and drainage projects. His work, extending over all portions of the country, has made him well-known throughout the United States as a capable engineer, an energetic executive, and as a faithful and honest man.

Mr. Richardson was married on October 4, 1888, to Miss Nellie Symonds who, with three sons, survives him.

Mr. Richardson was elected a member of the Boston Society of Civil Engineers on March 21, 1894. He was also a member of the American Society of Civil Engineers, the New England Water Works Association and the Engineers' Club of New York City.

EDWARD D. BOLTON.*

Edward Davis Bolton was born in Somerville, Mass., October 14, 1849, and died at New York, March 10, 1916.

He was the son of John B. and Sarah A. (Davis) Bolton; was educated in the public schools of his native city and the Massachusetts Institute of Technology.

Leaving the Institute in June, 1868, he entered the office of S. L. Minot, C.E. (in the old Barristers Hall, Boston), where he was employed in general railroad work on the Old Colony, Boston & Albany and Boston & Providence railroads, and in surveys and construction of various branches and additions to these railroads.

He remained with Mr. Minot until February, 1875, when he entered the office of Ernest W. Bowditch (then Bowditch & Copeland), of Boston. Here he was engaged in a large variety of work of general engineering, landscape work, sewerage and water works, and had general charge of the office during the absence of Mr. Bowditch in Europe.

* Memoir prepared by Frederic M. Hersey and Daniel W. Pratt.

In March, 1888, he left Mr. Bowditch and entered into the business of general contracting for engineering work with Mr. T. William Harris, and later for himself in contracting and engineering work. From April, 1891, to July, 1892, he was with the Cataract Construction Company; and in July, 1892, he went with Olmsted, Olmsted & Eliot as superintendent of construction.

He remained with Messrs. Olmsted for three years or more, when he went to New York and was employed for several years in the public works of Brooklyn, as assistant engineer in the department of sewers, in which latter work he was engaged at the time of his death.

Mr. Bolton's father was an expert steel engraver, and the same talent was evident in the work of the son, who was a superior draughtsman as well as engineer.

When a student at the Institute of Technology, his associates speak of him as "a young man of gentle bearing and quiet, unassuming manners; of slender physique, but with abundant strength of character, diligent and faithful in all things and a true friend to his fellows."

His associates in later years feel that his promise as a student was fulfilled in his life work — leaving a record for ability, honesty and integrity.

He joined the Boston Society of Civil Engineers October 21, 1896.

Mr. Bolton married Dora M. Lovering, and is survived by her and two sons — Harold L. Bolton, of East Orange, N. J., and Ernest D. Bolton, of Hillsdale, N. J.

FRANK EDSON SHEDD.*

Frank Edson Shedd was born in Sharon, N. H., on July 18, 1856. He attended the Conant High School of East Jaffrey, N. H., and entered Dartmouth College, from which he was graduated in the Class of 1880.

After a year of teaching, as principal of a high school, Mr.

* This memoir, originally prepared by Mr. Frank W. Reynolds for the American Society of Civil Engineers, is submitted with certain minor changes by Mr. Chas. T. Main.

Shedd entered the service of the United States Coast and Geodetic Survey, where he remained for a year, his work being on the charting of the coast of Maine. In 1882, he left the service of the Government to take up civil engineering in Lowell, Mass.

In 1886, Mr. Shedd had charge of the erection of the Washington Mills, at Lawrence, Mass., at that time one of the largest mill construction propositions which had ever been undertaken. These mills are now owned by the American Woolen Company.

In April, 1887, he became a member of the staff of Lockwood, Greene & Company, the engineering firm which had designed the Washington Mills, and two years later was made first assistant to Mr. Stephen Greene, then the sole member of the firm. From that time until his death, Mr. Shedd maintained an intimate connection with that organization.

On January 1, 1901, on the incorporation of Lockwood, Greene & Company, Mr. Shedd became a director and the vice-president of the firm, and held both these positions until his death. He was a civil engineer of high standing, and had designed many large mills and hydraulic plants in various parts of the United States and Canada, having been considered one of the leading authorities in this country on hydraulic developments.

Mr. Shedd was a man of varied interests; a member of the American Society of Civil Engineers and of the American Society of Mechanical Engineers, he was also a member of St. John's Lodge, A. F. and A. M., of Boston, a Companion in the Mount Vernon Royal Arch Chapter, and a member of the Second Parish Congregational Church, of Dorchester, Mass.

Mr. Shedd was also a member of the New Hampshire Historical Society and a life member of the New England Historic Genealogical Society. He was the founder, as well as the secretary and treasurer, of the Shedd Family Association, and designed the handsome monument,— erected at Shedd's Neck, in Quincy, Mass., three weeks prior to his death, by the Shedd Association, — in honor of the first ancestor of the family in America. Having been for many years much interested in genealogical research, he had collected many valuable data regarding the Shedd descendants in America, and was

making plans, when taken sick, looking toward the early publication of a genealogy of the family.

Mr. Shedd was a thorough, painstaking engineer, of retentive memory, wise judgment, and tireless industry; a modest, unobtrusive gentleman of sterling character. One of his friends says of him:

"He was a high-minded citizen and represented the highest ideals of human life; he rendered a large service to his fellowmen; he was an honor to his profession and has left behind him a name which ought to be an inspiration and help to us all for higher and better things."

During his illness, which covered the last six months of his life, Mr. Shedd suffered much, but bore his sufferings with great fortitude, and attended to many affairs up to the very last. He died at his home in Dorchester, Mass., on September 22, 1916, leaving a widow and one son.

Mr. Shedd was elected a member of the Boston Society of Civil Engineers on April 19, 1905.

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PAPERS AND DISCUSSIONS

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HISTORY AND PRESENT STATUS OF THE CONCRETE PILE INDUSTRY.*

By Charles R. Gow, Member Boston Society of Civil Engineers.†

Prior to the beginning of the present century, piling for foundation purposes as used in this country was almost invariably of wood. It is true, of course, that special conditions had at times imposed the necessity of introducing substitutes for wood piling, and the use of iron and screw piles was more or less familiar to engineers of that period. Sand piles had been used in a limited way, and the writer recalls having seen light steel shells filled with concrete and buried in the ground as foundation supports during the late years of the last century.

It was generally recognized, however, that wooden piling although relatively cheap was poorly suited for many of its requirements. The necessity of cutting wooden piles below permanent ground water level frequently required excessive amounts of excavation and correspondingly large masses of masonry to bring the footings to grade. If the ground water level was in any way liable to future depression, there was justification for more or less apprehension as to the future integrity

Note. This paper is issued in advance of date set for its presentation. Discussion is invited, to be received by W. L. Butcher, Editor, 14 Beacon Street, Boston, before August 10, 1917, for publication in a subsequent issue of the Journal.

* This paper was presented before the American Concrete Institute, February 9, 1917.

† Charles R. Gow Co., General Contractors, 166 Devonshire Street, Boston.

of the structure which the pile supported. Again, the amount of loading which could be applied safely on wooden piles was comparatively small. The liability of breakage during the process of driving was also recognized by engineers, as was the fact that such breakage could not always be readily detected by means of surface indications.

These and other considerations have called for the exercise of ingenuity on the engineer's part in providing a satisfactory substitute for wooden piles which would eliminate their disadvantageous features. The general adoption of concrete as a building material during the late years of the past century naturally led to its introduction for various structural purposes and it was soon applied as a means to take the place of wooden piling. From that time on, the application of concrete to the piling industry enjoyed a rapid and encouraging growth, and to-day its use throughout the world has assumed very substantial proportions. The experimental stage has long since passed, and we now universally accept the concrete pile in its many forms as an available expedient for the solution of our physical and economic foundation problems.

In the development of the concrete pile industry there have ensued two distinct types or groups, viz., those which are precast on the surface and later driven in substantially the same manner as are wooden piles, and the so-called "built-in-place" piles, which are cast in their final positions after the necessary opening in the soil has been obtained by means of temporary or permanent forms or shells. These two types of piles will be treated separately.

Pre-Cast Concrete Piles.

It was natural that the earlier adaptations of concrete to piling should follow in form and methods the previous experience with wooden piles. Accordingly, concrete piles were first cast in molds of approximately the dimensions of heavy wooden piles, or somewhat larger, and in general a rectangular cross-section was adopted for convenience rather than the circular shape. The first piles of this type to be used, so far as there is record, were introduced in France by Hennebique during the

year 1896, and their introduction into the United States followed some years later. Generally speaking, pre-cast piles are built with a square, hexagonal or octagonal cross-section. When the square section is adopted, it is customary to chamfer the corners slightly, in order to avoid the danger of chipping during handling. The piles are usually cast with a diameter of from 12 in. to 24 in., depending upon their length and the load they are to carry.

This type of pile is almost invariably reinforced with some suitable arrangement of longitudinal bars and circumferential hooping. In many instances the hooping consists of a spiral winding either of wire or small-sized round or flat bars. In a number of instances, sheets of electrically welded wire fabric have been utilized as reinforcement in piles of moderate length, the heavier wires of the mesh extending in the longitudinal direction, while the lighter strands serve as transverse hooping. In some instances, additional reinforcement is provided near the top of the pile to resist the tendency for the head to rupture under the impact of the hammer. Similarly, in the case of very long piles, extra longitudinal rods are used to strengthen the middle section against stresses due to preliminary handling. While the method described above is the customary practise in reinforcing these piles, other types of reinforcement may be and have been adopted, as, for instance, angle irons connected by lattice bars or even I-beams incased in concrete, the object being always to insure the necessary strength to withstand the stresses which may be induced in the pile due to handling, driving or loading. In the ordinary case, it usually will be found that the greatest stresses will be developed when the pile is picked up in a horizontal position and supported by means of a single fastening at the middle of its length.

Protection at the point is often afforded by the use of a cast-iron steel point or shoe (Fig. 1), which usually is cast integral with the pile and secured to it by means of adequate anchorage. The function of this special point is, of course, to prevent breakage at the tip of the pile during driving, which might result from encountering bowlders or other obstructions.

In many cases a jet pipe is provided for in casting the pile,

and may be readily formed by building in a length of ordinary wrought-iron pipe longitudinally in the center of the pile. This pipe may project sufficiently at the top to permit of attaching the discharge hose from a jet pump, and the lower end is usually reduced where it emerges from the point so as to form a nozzle.

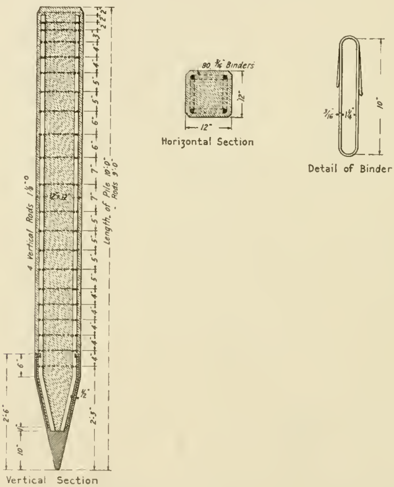

FIG. 1. SQUARE (UNPATENTED) REINFORCED CONCRETE PILE USING STEEL PROTECTING POINT.

The writer has found that a cheap variety of tin speaking-tube will answer all purposes of the longitudinal passage in the center of the pile, and this tube may then be connected at either end by short pieces of wrought-iron pipe, which serve as hose connection and nozzle respectively. It is often found convenient to introduce a water jet through a horizontal nipple in the side of the pile, a short distance below the head, and to connect this nipple with the longitudinal passage by means of a right-angle

elbow. This arrangement eliminates certain difficulties in operating the jet during the driving process.

Pre-cast piles are sometimes built with a longitudinal taper. Sometimes they are of uniform section throughout, while still others are uniform in section except for a short length near the tip, which is tapered to give a long, wedge-shaped driving point.

In a few instances, piles have been cast with a hollow section when it was desired to obtain a maximum of stiffness with a minimum of weight. These are naturally more expensive to build, and the type is not especially common.

None of the above features is patented, and any of them may be adopted at will. Such patents as have applied to the pre-cast type of pile are usually confined to one or more special features either in the details of design or in the method of making and driving. These features are supposed to afford better results in many respects than ordinarily could be obtained by means of the unpatented types.

Among the special patented types of pre-cast piles in more or less common use at the present time, in this country, may be mentioned the following:

The Chenoweth Pile.

The "Chenoweth" pile, patented in 1904 by Mr. A. C. Chenoweth, of Brooklyn, N. Y., depends chiefly for its patentable features upon the novel method of its manufacture. This and the resulting arrangement of its reinforcing metal give to it special properties which materially assist in facilitating its safe handling and driving. The pile is circular in cross-section, with a variable diameter from 12 in. upward, dependent upon the length of the pile required. This pile is formed in the following manner (Fig. 2):

A slightly inclined table is constructed of a length somewhat in excess of that of the pile to be made. This table is free to move laterally upon suitable rolls. Near the upper edge of the inclined table is secured a length of 2-in. pipe, capable of being revolved. To this pipe is attached one longitudinal edge of a sheet of expanded metal or fine wire mesh, which is spread flat upon the surface of the inclined table. Upon this sheet of metal

fabric, longitudinal reinforcing rods are laid at intervals and wired to the mesh. A layer of moderately stiff concrete is then spread over the prepared reinforcement and shaped by means of a template so as to conform to certain necessary requirements. The 2-in. pipe is now revolved, drawing the table with its contents toward it as the combined layers of steel and concrete are wrapped about it. Simultaneously, a heavy roll immediately above the 2-in. pipe bears against the outer surface of the pile, imparting to it the required cross-section. After the rotation

Fig. 2. Construction of Chenoweth Pile.

is completed, the pile is bound at frequent intervals with small wires. It will be seen that the resulting pile section resembles somewhat the arrangement of the layers in a jelly roll, the metal fabric with its attached longitudinal rods forming the spiral hooping which affords great strength against stresses due to handling and driving.

The Corrugated Pile.

The "corrugated" pile (Fig. 3), patented in 1908 by Frank B. Gilbreth, of New York, is octagonal in section, with a uniform

taper from 20 in. to 11 in. It is reinforced with a circular cage of Clinton electrically welded wire fabric. Its patentable features consist chiefly of longitudinal semicircular corrugations in the middle of each of its eight exterior faces and of a tapered cored passage in the center of the pile, which is formed by casting a wooden mandrel in the center of the pile having a 4-in. diameter at one end and a 2-in. diameter at the opposite end. The large end of this wooden mandrel projects sufficiently through the end of the form so that it may be given a slight turn after the concrete is partially set, thus breaking its bond with the concrete and permitting its easy withdrawal when the concrete is thoroughly hardened. The purpose of the corrugations is intended to be twofold. First, to afford a ready passage for the water returning from the jet pipe to the surface, and, second, to increase the total perimeter of the cross-section, thereby making possible a greater frictional contact with the soil. The cored passage in the center of the pile serves as a means for the introduction of the jet pipe and thereby eliminates loss which would ensue through building a separate pipe in the center of each pile. So far as the efficacy of the corrugations is concerned, it may be questioned whether they add in any way to the ease of driving. It would seem that the increased perimeter might better be obtained by the adoption of a square rather than an octagonal section, though it may be argued that an equivalent superficial area is obtained in this manner with a less amount of concrete. This type of pile enjoyed a certain degree of popularity for a time but has been little used of late years, so far as the writer is aware.

Fig. 3. Corrugated Concrete Pile.

The Cummings Pile.

The "Cummings" pile (Fig. 4), patented by Mr. R. A. Cummings, of Pittsburg, Pa., is distinguished from the unpatented types chiefly by the introduction of a special design of reinforcement in the head of the pile which avoids danger

of breakage at the point. A series of circumferential and spiral flat bands is inserted in the head of the pile, and it was found by testing one of these piles to destruction, under repeated blows of a heavy hammer, that the pile ultimately failed by the breaking of the hooping in the body of the pile while the specially reinforced head remained intact, indicating that it is possible by some such means to secure sufficient strength to meet the severe stresses due to impact. On the other hand, with the adoption of suitable cushion caps, it has been found possible in the majority of instances to avoid the kind of breakage which this patented type provides against. Nevertheless, it is undoubtedly true that there are cases where very severe driving

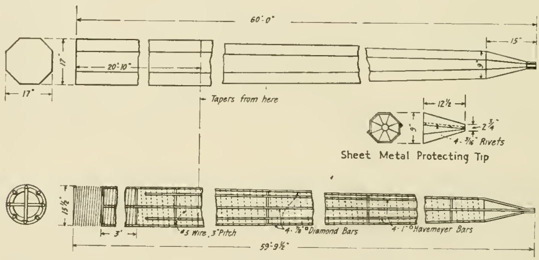

FIG. 4. DETAILS OF CUMMINGS (PATENTED) PRE-CAST PILE.

becomes necessary, in which case some such provision may be necessary if damage to the pile head is to be entirely avoided. This type of pile was successfully used in the construction of the Farmville Bridge across the Appomattox Valley, on the Norfolk & Western Railroad, where 60-ft. piles were driven through an old fill allowing only $\frac{3}{4}$ in. average penetration per blow. Under such conditions it is obvious that some special protection is needed to maintain the integrity of the pile head.

The Bignall Pile.

The "Bignall" pile (Fig. 5) is patented and is controlled by the Bignall Piling Company, of Lincoln, Neb. Its main

patentable feature consists of a double jetting system. A 4-in. jet pipe extends longitudinally through the center of the pile, being reduced at the pile point to $1\frac{1}{8}$ in. This 4-in. pipe is tapped at frequent intervals and connected by means of $\frac{3}{4}$-in. nipples with the four outer faces of the pile. The outer extremities of these nipples are turned upwards by means of right-angle elbows. In addition, a 2-in. jet pipe is inserted inside the 4-in. pipe and connected with the $1\frac{1}{8}$-in. nozzle at the point. By

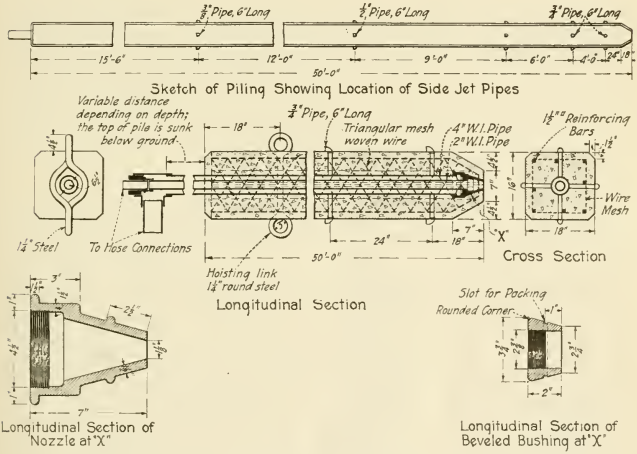

FIG. 5. THE BIGNALL (PATENTED) PILE.

this means two separate jet processes are carried on simultaneously. The 2-in. pipe operating under high pressure delivers a jet stream in the usual way at the point of the pile, while the various $\frac{3}{4}$-in. connections permit water at a somewhat less pressure to escape upwards along the four faces of the pile, thereby destroying all frictional resistance and permitting the pile to sink into place by its own weight. This type of pile is usually handled by a derrick or crane, and no pile driver or hammer is deemed necessary. On the reconstruction of the Platte River

Bridge of the C., B. & Q. Railroad, at Ashland, Neb., piles of this type were used. They were 15 in. square in section, 50 ft. long, and weighed 6.2 tons. Two independent pumps were operated, one to give a nozzle pressure of from 200 to 300 lbs. per sq. in. and the second to deliver water to the side jets at from 100 to 150 lbs. per sq. in. It is reported that the average time of sinking a 50-ft. pile in this manner was forty-two minutes. The piles are reported to have cost 53 cts. per lin. ft. to manufacture, and 15 cts. per lin. ft. to sink. The total estimated cost of the completed pile was $1.00 per lin. ft. for piles not to exceed 50 ft. in length. It seems probable that this method of sinking might be quite satisfactory in certain classes of material, such as sand and gravel. There might, however, be some question of the sufficiency of the jet method alone in many materials such as clay and hard pan or some classes of rough fill.

The Giant Pile.

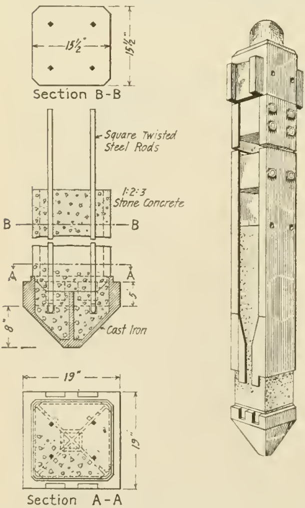

Fig. 6. The Giant (Patented) Pile.

The "Giant" pile (Fig. 6) is patented and controlled by the Giant Concrete Piling Company, of New York. Its patentable feature lies principally in the method of driving the pile. A cast-steel point is built integral with the pile. The upper flanges of this point project about $1\frac{1}{2}$ inches beyond the concrete faces of the pile itself. A driving frame, consisting of two channel irons incasing two sides of the concrete pile for their entire length, rests at the bottom upon the projecting edges of the cast-steel shoe. A specially designed head is attached to the channel iron frames and receives the blows of the hammer. By this means

the entire force of the hammer blow during driving is transmitted directly to the cast-steel shoe, and no strains are induced in the concrete itself. When the piles are driven, the channel iron frames are withdrawn, to be used again on the next pile. The space which is left in the ground when the frames are withdrawn must be filled by the closing in of the soil against the surface of the concrete pile. Undoubtedly this arrangement permits of very severe driving without endangering the integrity of the pile itself. While it is probable that in a majority of cases the surrounding soil will close around the pile after the frames are withdrawn, it may be considered problematical whether the apparent friction observed in driving is reproduced after the frames are withdrawn.

Method of Manufacture of Pre-Cast Piles.

Pre-cast piles are usually concreted in a horizontal position. In some of the earlier instances it was deemed necessary to cast them in vertical forms in order that the stratification of the concrete might be normal to the direction of the load. This method of manufacture, however, adds very considerably to the cost of the pile, and it is very doubtful in the writer's opinion whether there is any compensating advantage. It is the almost invariable custom in pile making to use a wet mixture of concrete which has very little if any stratification. It seems likely that, in cases where additional strength is required over that obtained on the ordinary horizontal method of casting, it might be more economically obtained by increasing the richness of the mixture rather than to adopt the very expensive method of casting in vertical forms.

Because of the ease and simplicity of form construction, the square section of pile has become, generally speaking, the most popular (Fig. 7), although hexagonal and octagonal shapes are still used (Fig. 8), but only to a limited extent. The square section also commends itself because of the greater surface area exposed to friction. If for any reason a circular section is desired, it can sometimes be secured by selecting a casting yard having a pronounced inclined slope so that the angle of the forms

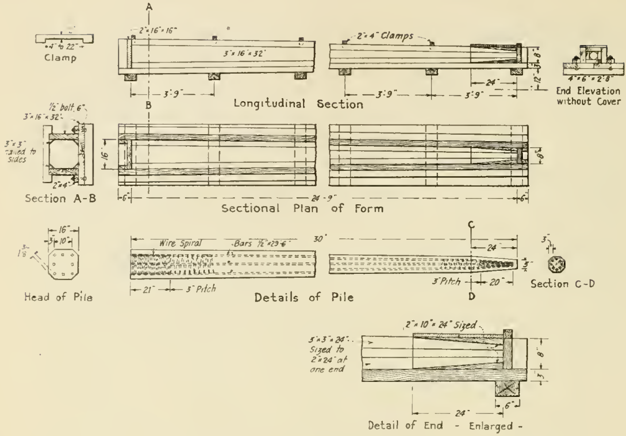

FIG. 7. PRE-CAST CONCRETE PILE (SQUARE) AND FORM.

will permit pouring through the end, otherwise vertical forms will be necessary.

Because of the requirements of a homogeneous mixture of concrete and early strength, pre-cast piles are seldom or never made with a mixture leaner than 1, 2 and 4, and occasionally a richer mix is deemed advisable. It is safe to say, however, that by far the great majority of pre-cast piles are now made of the first-named mixture.

It will be found desirable, in any given case, to devote a considerable amount of thought to the design and construction of the form work used in casting concrete piles. Above all, it is essential that an unyielding base should be provided under the forms, so that unequal settlements will not cause damage to partially set piles. Various and ingenious contrivances and

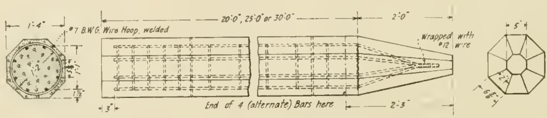

FIG. 8. PRE-CAST OCTAGONAL PILE.

arrangements of form work have been designed from time to time. Figs. 9 and 10 illustrate typical cases.

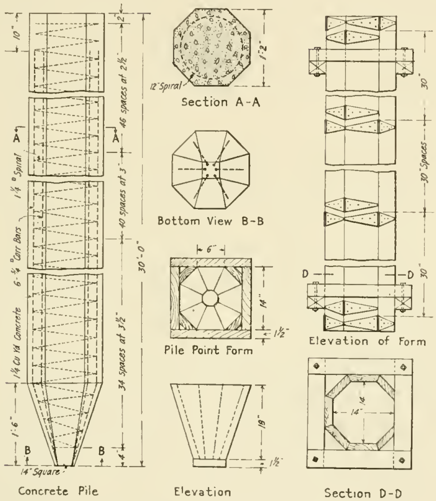

FIG. 9. FORM FOR CASTING CONCRETE PILE.

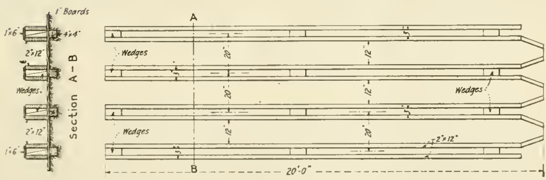

FIG. 10. ARRANGEMENT OF FORMS FOR CASTING CONCRETE PILES.

The fabrication of the reinforcement should also have careful attention. A simple contrivance for economically preparing spiral hooping is shown in Fig. 11. Extreme care is absolutely essential in placing the reinforcement. The reinforcing metal

is usually assembled as a unit so that it may be lowered into the form and accurately centered before the placing of the concrete begins. If a metal point is to be used, it is fitted in place in the end of the form prior to concreting. The sides of the forms can generally be removed in from twenty-four to forty-eight hours after casting, and are then available for use in subsequent forms. Under normal weather conditions, pre-cast piles do not acquire sufficient strength to permit of handling or driving inside of twenty-eight to thirty days after casting. This feature necessitates the use of a very considerable area as a casting yard in order to maintain a sufficient number of properly cured piles

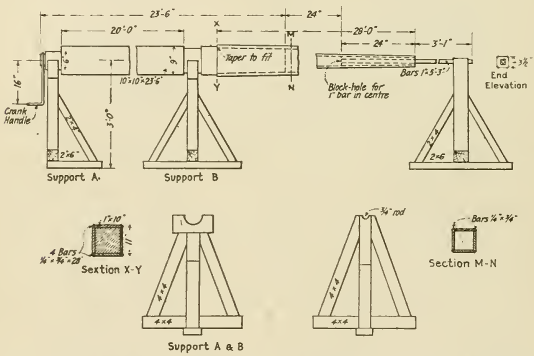

Fig. 11. Mandrel for Winding Wire Coil for Reinforcing Concrete Piles.

for driving at all times. It has been found that the proper ageing of pre-cast piles may be materially accelerated by the adoption of steam curing methods. The piles are assembled in tiers and enclosed with some suitable form of covering under which live steam is fed continuously. The combination of heat and moisture hastens the set of the concrete without injury, so that they may be handled and driven in some cases within a week of the time of casting.

Unless piles are adequately reinforced to resist rough

handling in the preliminary stages of the work, a considerable degree of care is necessary in moving them to the driver and in raising them to a vertical position (Fig. 12). While piles in lengths up to 25 or 30 ft. may be designed to stand readily a maximum stress due to handling, it will be seen that the longer lengths would require cross-sections of prohibitive dimensions if this provision were to hold in their case. It is, therefore, usually necessary in the handling of long piles to use special

FIG. 12. HANDLING 51-FOOT PILE WITH CENTER SUPPORT ONLY.

precautions which will relieve the pile from undue strain. This is generally possible by means of multiple supports during the lifting and righting operations. In the case of piles measuring from 30 to 50 ft. in length, it will be found possible to handle the pile successfully by means of a bridle chain attached at one point near the head and the other near the center of the pile (Fig. 13). In lifting, the strain is thereby distributed at the two points, and as the pile is raised into a vertical position no excessive force at any time operates to overstrain the steel or concrete. Piles in excess of 100 ft. in length and measuring

20 in. by 20 in. in cross-section have been successfully handled by similar methods except that two bridle chains were used,

Fig. 13. Raising Pile to Vertical Position.

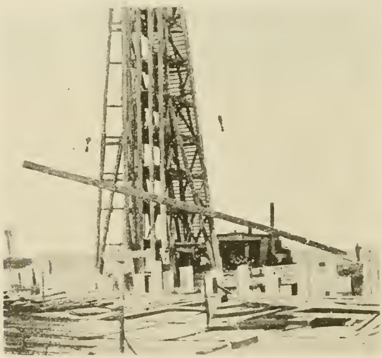

Fig. 14. Bridle Chains for Handling Long Pre-Cast Concrete Piles.

permitting support at four points on the pile (Fig. 14). The rule which seems to be in most common use for lifting long piles has been to attach the hoisting falls at points 20 per cent. of the pile length from either end (Fig. 15). In some cases it has been found convenient to insert pipe nipples transversely through the pile section at the points where the lifting strain is intended to be applied (Fig. 16). A pin or bar may then be inserted in the hole thus formed, which assures the application of the lifting strain at the desired point.

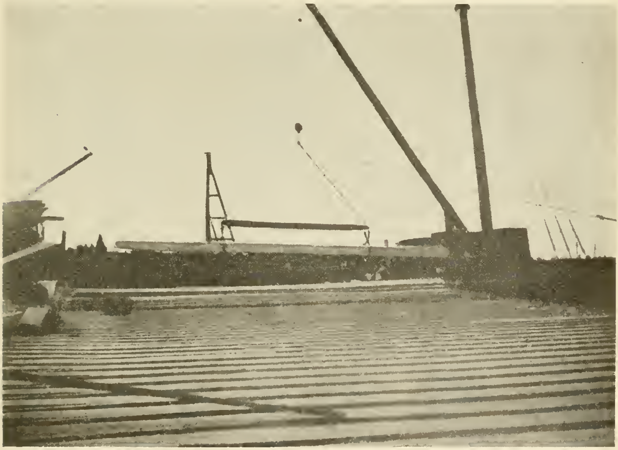

FIG. 15. BRIDLE CHAINS FOR HANDLING CONCRETE PILES.

One of the drawbacks in the way of using concrete for the purpose of piling is the inability of the material to withstand heavy direct blows without fracture. This difficulty, however, has been largely overcome by the introduction of certain protecting devices which either resist the breaking stresses or cushion the blows to such an extent that the hammer impact has no harmful effect. Naturally much energy is lost by the introduction of this cushion between the hammer and pile head, there-

fore the least cushion required, the more effective the hammer blows become in causing penetration. For this reason many designers of pre-cast piles introduce additional reinforcement in the head of the pile. In the construction of the St. Louis Viaduct, steel bands 12 in. by 12 in. by $\frac{1}{8}$ in. were cast integral with the head of each pile. Although there had been much breakage of pile heads on this job prior to the adoption of this banding method, no breakage occurred in the case of subsequent piles. At the normal price of steel plate, this form of protection would add not more than four cents per linear foot in the case of 25-ft. piles. The "Cummings" pile, as previously noted, is especially reinforced in a most effective manner against breakage at the

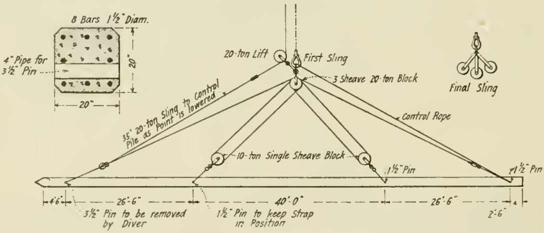

FIG. 16. METHOD OF SLINGING 100-FOOT CONCRETE PILES USED AT AUCKLAND, NEW ZEALAND.

head. Even in these cases, however, if hard driving is required, some form of cushion will nevertheless be required if damage to the pile is to be entirely avoided. Various types of driving caps have been devised for this purpose, and the essential features of all such caps are similar. They are made of steel or cast iron, and contain a recess in the bottom which fits the head of the pile, and a depression in the top in which is usually inserted a hard wood block to receive the blows of the hammer. Between the wooden block and the head of the pile is placed a layer of some cushioning material such as sawdust, sand, rope mats, or layers of rubber hose or belting. In general, the cast-iron caps seem to have given the most satisfactory service, and where the cap has been made of riveted steel plates there has seemed

to be more or less difficulty due to the loosening and shearing of the rivets. The wooden blocks require frequent replacement, but otherwise the cap is used continuously. It is customary to equip these caps with a wire-rope strap, by means of which they may be temporarily attached to the hammer and thus raised or lowered from the pile head. It is also desirable to construct the cap with some form of grooves which fit the leads of the pile driver and thus cause it to guide the head of the pile. Details of construction of various types of driving caps are shown in Figs. 17, 18 and 19.

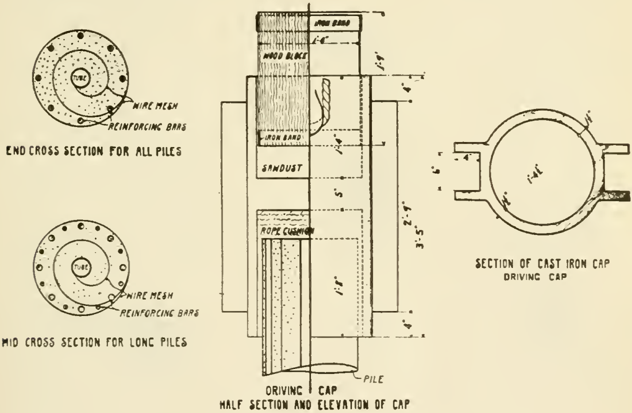

FIG. 17. TYPE OF DRIVING CAP.

There has been much controversy as to the type of hammer best adapted for driving concrete piles. Some authorities have maintained that the drop hammer is superior for the purpose to the steam hammer. Other experienced pile drivers maintain that the steam hammer excels, and among the steam hammer adherents there is some disagreement as to whether the single or the double acting hammer is to be preferred. After a consideration of all the arguments pro and con, on this question, it seems reasonably safe to assume that, whichever type of hammer

is used, the heavier it is the more successfully it will drive the pile. Because of the great mass of the pile itself, it is obvious that a large proportion of the force of the hammer blow will be expended in overcoming its inertia; therefore light hammers of either variety should be avoided in the driving of concrete piles. It seems to the writer a significant fact that, in the very great majority of concrete pile-driving jobs, the steam hammer is selected in preference to the drop hammer, and it would appear

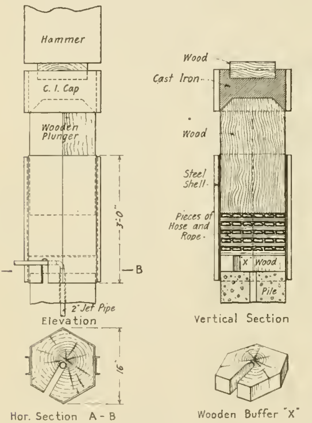

FIG. 18. TYPE OF DRIVING CAP.

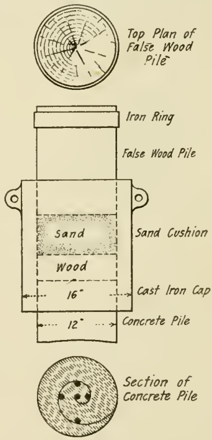

FIG. 19. TYPE OF DRIVING CAP.

to be a fair presumption that it must on the whole, therefore, possess advantages over the drop hammer.

As to the double-acting steam hammer, it has not apparently enjoyed any considerable degree of popularity in the driving of concrete piles up to this time. It is reported that, in the driving of concrete piles for the St. Louis Viaduct, a 5 000-lb. double-acting steam hammer was used at the beginning, and much difficulty was experienced because of the frequent breaking of pile heads. Finally the ram itself was broken, whereupon a

No. 1 Vulcan 10 000-lb. single-acting hammer, with a 5 000-lb. ram and a $3\frac{1}{2}$-ft. stroke, was substituted, and no further difficulty from breakage was experienced. The progress with the double-acting hammer had averaged 9 piles per day, and this output was increased to 17 per day after the introduction of the heavier single-acting hammer. With regard to the breakage of pile heads referred to, it is not clear why the type of steam hammer should cause such a difference, and it seems possible that the subsequent immunity from breakage might more properly be attributed to the use of the steel bands previously referred to in connection with these piles. The economy of the heavy over the light hammer, however, is well illustrated by the increased progress shown in this instance. The heaviest hammer so far used for this purpose was employed in driving pre-cast piles for Pier No. 2 of the Intercolonial Railway, at Halifax, N. S. The piles were 24 in. square, 57 to 77 ft. long and driven to rock, the largest pile weighing 23 tons. A 28 000-lb. double-acting steam hammer was used in driving them. From 200 to 1 800 blows were required to drive these piles to rock, final penetration being 1/30 in. It is reported that only two pile heads were broken, out of the 1 800 piles which were driven on this job. The heads of the piles were protected by 3-in. spruce planks, upon which rested a cast-steel follower of hollow pattern and with top and bottom flanges. The top flange contained a depression in which was placed a wooden block 15 in. thick and bound with steel bands. Some blocks lasted for the driving of only two piles, while others served as many as twenty. They usually failed by the bursting of the bands. An average of 10 piles in ten hours was maintained on this work, with a maximum rate of 18.

In all cases where a drop hammer is used, the best results may be expected by employing as heavy a hammer as possible and using a small drop.

Another question which appears to remain somewhat unsettled is that of the relative merits of the straight and tapered pile. Undoubtedly the tapered pile may be driven more easily than the straight pile, especially when the water jet is not employed, and it also seems reasonably clear that if the entire length of the pile rests in a homogeneous material, the tapered pile may

give equally satisfactory results as a support for the load it carries. The fact is, however, — no matter how much we may theorize, — that the primary object in using piles ordinarily is to carry the load through an unsatisfactory type of soil and transmit it to some more reliable stratum at a lower depth. It is not, generally speaking, conservative practice to attach any value whatever to the frictional supporting power of the unsuitable strata immediately below the surface, and, as a matter of fact, we are chiefly dependent for our supporting power upon the amount of penetration which the pile has in the good material below. It seems, therefore, to be highly desirable that the pile shall have its maximum section and frictional surface area at this level where it will do the most good. The writer is, therefore, inclined to agree with the adherents of the straight-sided pile. This, of course, does not preclude the tapering of piles at the point or even a short distance above the point, and in many classes of soil such pointing is desirable in order to facilitate easy driving. It cannot be denied, of course, that tapered piles have been successfully driven in innumerable cases with entirely satisfactory results, but in the writer's estimation this of itself does not justify an opinion that they are superior in supporting power to the straight pile, the displacement of which is greater, the soil compression consequently being greater, and the resulting surface friction between the ground and the pile being also, in his opinion, much in excess of that of the tapered pile.

It has become a more or less general practice, in the driving of concrete piles, to utilize the assistance afforded by the water jet as an aid to rapid and effective driving. This expedient is especially helpful when the material through which the pile is driven consists of sand or gravel, materials which offer a maximum of resistance in their normal state and which present little resistance when eroded by the force of a powerful water jet. The efficiency of this jet in driving through clayey soils is not so marked, and much greater force is required to displace this material. Ordinarily, a pressure of from 100 to 150 lbs. per sq. in. is ample for jetting piles. As previously indicated, it is sometimes customary to provide a water passage by means of a

pipe or other longitudinal opening through the center of the pile. The delivery hose from the hydraulic pump may then be attached at the top of the pile to deliver the water through a nozzle at the point. Some authorities maintain that better results are obtained when two jet pipes are used on opposite sides of the pile. A committee of the American Railway Bridge and Building Association has recently compiled information with respect to the methods adopted by various railways in driving piles. The use of the water jet was found to be more or less general, and was used chiefly in sandy or gravelly soils or where deep penetration is required. It was found that the jet pipes used varied in sizes from $2\frac{1}{2}$ to $1\frac{1}{4}$, and nozzles from no contraction to $\frac{1}{2}$ in. in diameter. The water pressure used varied from 100 to 225 lbs. per sq. in., and pumps with 3-in. to 4-in. diameter discharge pipes were generally used. A large volume of water at moderate pressure was stated to give the best results. It was also reported that on the St. Paul, Minneapolis & Omaha Railway a steam jet was sometimes used in place of water. This method was found to work satisfactorily.

When a water jet is employed in connection with the driving of concrete piles, it will be found advantageous to churn the pile up and down in the hole made by the jet. In such cases the hoisting fall of the pile driver is attached to the head of the pile, the jet pump started, and when the jet has begun to operate, the pile is lifted 2 or 3 ft. and allowed to drop of its own weight. In this manner the soil is scoured from below the pile and softened to such an extent that it permits the falling pile to penetrate a substantial distance at each drop. In sandy soils it is usually possible to sink a pile for the greater part of its length in this manner, and driving is then only required for the last few feet of penetration (Fig. 20).

In some instances, where the soil possesses some cohesion, it will be possible to make a vertical hole in the ground with the jet alone into which the pile may be dropped for the greater part of its length. This method will be quite applicable when the soil is composed of fine sand with a slight amount of clay in it.

It is often desirable, in wharf or pier construction where piles are subjected to the force of the waves, to anchor them in

some manner which will prevent their becoming loosened. With this idea in mind, bulb-shaped footings 3 ft. in diameter and attached to concrete piles have been successfully jetted into place through sand.

Sometimes it becomes necessary to drive concrete piles through very rough material containing bowlders or other obstructions. In such cases a small-sized pilot pipe may be driven

FIG. 20. SINKING PILE BY WATER JET AND "CHURNING."

into the ground until it meets the obstruction. A charge of dynamite may then be inserted and exploded with the purpose of breaking up the rough ground and permitting the pile to be driven through it.

BEARING POWER OF PRE-CAST PILES.

The supporting power of a pre-cast pile will depend upon a variety of factors. If the piles are driven to ledge, they become columns, so far as their load capacity is concerned, except

that in general they are supported against lateral deflection and also they undoubtedly transmit at least a portion of their load by means of friction to the soil above the ledge. In such cases the load should be apportioned to the piles in proportion to the safe compressive value of their minimum sectional area. If the amount of penetration of the pile in good material is small, it will be seen that a tapered pile figured as a column will suffer in comparison with the straight pile so far as its safe supporting value is concerned. It is sometimes customary to figure the aggregate capacity of a column pile as equal to the combined safe compressive values of both the steel and concrete in its sectional area. Figured on this basis, it will be apparent that a pile of relatively small sectional area may be permitted to carry a very considerable load as a column, secured as it is against lateral deflection. It has already been stated that the piles for the Halifax Terminal Pier, which were 24 in. square in cross-section and up to 77 ft. in length, driven to rock, were loaded with 100 tons each. The same considerations which apply to pre-cast piles bearing upon ledge may with slight modifications be assumed to hold in cases where the pile is driven to an unyielding hardpan overlying ledge. In either of these cases it will be obvious that the straight pile is superior to the tapered pile in point of safe carrying capacity.

When the supporting power of the pile depends entirely upon its frictional contact with the surrounding soil, there is far less certainty as to either its ultimate or safe load capacity. The same theory is usually applied and the same formula generally followed as in the case of wooden piles. The so-called *Engineering News* Formula, $L = \frac{2\ Wh}{S+1}$, where L equals the safe load in pounds, W equals weight of hammer in pounds, h equals fall of hammer in feet, and S equals penetration in inches under the last blow, has been extensively employed to determine the safe load which the piles are capable of supporting. There is an essential difference, however, between the wood and concrete piles which doubtless requires some modification of this formula. The relatively large mass of the pile itself consumes a considerable portion of the energy

of the blow in overcoming its inertia. It has been suggested by some authorities that the *Engineering News* Formula, if used, should be modified so as to take into account this factor, and the particular formula which has been proposed is $L=\frac{2\,Wh}{S\left(1+\frac{w}{W}\right)}$, where w equals the weight of the pile and W that of the hammer. The formula for single-acting steam hammer which has been generally adopted, viz., $L=\frac{2\,Wh}{S+.1}$, should presumably be similarly modified, in the case of concrete piles, to $\frac{2\,Wh}{S\left(1+\frac{.1\,w}{W}\right)}$. All formulae which have so far been proposed in connection with the use of the double-acting hammer are more or less unsatisfactory because of the difficulty of accurately determining the mean average steam pressure during the downward stroke of the piston. It probably would be safe in any event not to rely too much upon formulae for load capacity, but to decide the question upon the results of observed tests and apply the results thus obtained to the formulae in order to secure a coefficient which may be made to apply to the driving of subsequent piles on that particular job or under similar conditions. In case actual loading tests are not made, it will probably be well to limit the allowable load on ordinary types of concrete piles to a maximum of thirty tons. This assumed value seems justified in view of the fact that the various available records of test loads upon concrete piles having a reasonably good penetration into satisfactory soil have failed to disclose any failures due to settlement under loads below this amount.

Rate of Progress in Driving Pre-Cast Piles.

No rule can be laid down for determining in advance the probable progress to be expected in the driving of pre-cast concrete piles. Just as various attending conditions will vary the rate of progress in the driving of wooden piles, so also the number of concrete piles which may be driven in a given period will fluctuate accordingly. Undoubtedly the use of the water

jet has a marked influence in increasing the rate of driving. So also does the adoption of the heavier types of hammer. Even with these facilities, soils are often encountered which refuse to yield appreciably under their influence and recourse must be had to long-continued driving with small increments of penetration. Generally speaking, however, under the most severe conditions of driving, and taking a 25-ft. pile as a fair average of length, not less than six piles may be estimated as a day's work, while, with favorable conditions, as many as thirty to forty such piles have been driven by a single machine in one day. It may be assumed, therefore, that the expected daily average will lie somewhere between these limits; and with a prior knowledge of local conditions it will usually be possible to classify the relative difficulties so as to determine approximately what the probable output is likely to be.

Present General Practice in the Design of Pre-Cast Piles.

The Masonry Committee of the American Railway Engineers Association reported, about a year ago, on the current practice of several railroads in their reinforced concrete pile construction. It stated, among usual customs, that the transverse reinforcement used was generally $\frac{1}{4}$-in. rods, arranged either as a spiral or spaced hooping. Steel wire mesh was used for reinforcement in a few cases, and additional steel was sometimes used in the pile head. The weight of the steel per linear foot used by the several railroads ranged from $4\frac{1}{4}$ lbs. on the C., B. & Q. Railroad, to $12\frac{1}{2}$ lbs. on the Illinois Central and $17\frac{1}{2}$ lbs. on the Chicago, Milwaukee & St. Paul Railroad. Usually, 16 in. was the short diameter adopted, whether the section was square or octagonal. The Atchison, Topeka & Santa Fé Railroad used the formula $D = 7'' + \frac{1}{4}'' \times L$, where L equaled the length in feet and D the diameter of the pile in inches. The use of straight piles was found to predominate over the tapering type.

Cost of Pre-Cast Piles.

In common with all classes of underground construction, the cost of reinforced concrete piles varies with design and conditions. The cost of materials for any given case may usually

be determined with reasonable accuracy for any given locality. The labor cost of making and driving will vary widely, depending upon various contributory causes.

On the St. Louis Viaduct work, where the piles were $13\frac{1}{2}$ in. square and 25 ft. long, four $\frac{3}{4}$-in. round bars hooped with No. 8 spiral wire on 2-in. pitch were used as reinforcement. The labor making up the unit reinforcing cages cost from $1.00 to $1.25 per pile, with labor at 65 and 70 cts. per hour. The cost

FIG. 21. HANDLING AND DRIVING CONCRETE PILES.

of labor for casting these piles was 8 cts. per lin. ft., with labor at 40 cts. per hour. On the construction of the Yolo Bypass Trestle in the Sacramento Valley, Cal., 14-in. piles 32 to 50 ft. long were used, and the average cost of assembling and placing reinforcement, consisting of four $\frac{7}{8}$-in. round rods with spiral hooping, was $7.50 per ton. An average of 20 piles per day were cast, and 600 sets of forms were required, there being a total of slightly under 3 000 piles; 177 000 ft. board measure of lumber was used for forms exclusive of mud sills. The cost

of loading and hauling piles on a 3-ft. narrow-gage track for an average distance of $2\frac{1}{2}$ miles was 7.3 cts. per ton mile FOR LABOR ONLY.

The writer on one occasion kept a careful record of the cost of making and driving 412 concrete piles ranging in length from 8 to 40 ft. They were cast with a 13-in. square section reinforced by a cage of No. 3 Clinton Wire Cloth placed 2 in. from the outer surface. They were sunk with the assistance of a water jet introduced through a hole in the center of the pile formed by casting a line of $1\frac{1}{2}$-in. speaking tube in the longitudinal axis. The concrete mixture used was 1, 2 and 4. The soil consisted of mud, fine sand and some floating masses of clay hardpan. The piles were cast under cover in a sectional shed which was moved from time to time as required. They were handled by guy derricks, were held in upright position by a light portable timber framework which contained a pair of hammer leads, and were driven with a 2 800-lb. hammer operated by the derrick falls. (Fig. 21.) Twenty piles was the maximum day's work. A sounding was taken at the location of each pile, to determine accurately the necessary length of the pile in order that it should reach ledge. There was a total of 8 937 lin. ft. of piles cast and driven. The cost of the work in detail was as follows:

	Per Lin. Ft.	
Labor making soundings	$0.02	
Labor on forms	.035	
Labor casting, including placing reinforcement	.129	
Labor driving	.142	
Labor, Superintendent and miscellaneous	.128	
		$0.454
Materials for forms	.036	
Clinton wire reinforcement, $0.05 per sq. ft.	.167	
$1\frac{1}{2}''$ speaking tube for center jet hole	.026	
Concrete aggregates	.212	
Materials used for heating and covering	.025	
Ropes, blocks, chains, etc.	.044	
Coal	.023	
Miscellaneous supplies	.042	
Total for materials and supplies		$0.575
Total cost for labor and materials		$1.029

As this work was prosecuted in the winter time, it was somewhat more expensive than it otherwise would have been. The price per hour for labor at the time this work was done averaged about 20 cts.

Under the most favorable conditions it is unlikely that any pre-cast pile can be made and driven to-day at a contract price below $1.00 per lin. ft., and the cost is likely to range from this minimum to a maximum of $1.50.

Notable Instances of the Use of Pre-Cast Concrete Piles.

In addition to the case cited of exceptionally heavy concrete piles used at the Halifax Terminal Pier of the Intercolonial Railway, where piles upwards of 77 ft. in length and weighing 23 tons were successfully handled and driven, it may be noted that pre-cast piles of a maximum length of 106 ft. and 20 in. square were driven in the construction of Pier No. 35 of the San Francisco Harbor Development. This extreme length was made necessary because of the very considerable depth of alluvial deposit. These piles were designed to carry 40 tons each. Pre-cast piles 85 ft. in length and 20 in. square were used in the construction of piers in Havana Harbor in 1914. They were driven by a No. 1 Vulcan steam hammer, with an average of 500 blows per pile, and brought up with a penetration of $\frac{1}{8}$ in. They also were designed to carry a load of 40 tons per pile. Pre-cast piles 100 ft. in length were used in the construction of wharves at Auckland, New Zealand. They were driven through 50 ft. of mud and clay to rock. These piles were 20 in. square, reinforced with 8 long rods and weighed a maximum of 20 tons.

So far as the writer is aware, there have been reported no failures on the part of pre-cast piles to fulfill their intended purpose as foundations. In his opinion, considered solely from the standpoint of efficiency, the pre-cast pile is superior to the other types. They possess, however, some serious disadvantages which render their use less common than it would otherwise be. With the modern tendency to hasten construction at every stage, the loss of time necessary to permit pre-cast piles to be properly made and cured renders their use prohibitive in many instances. Ordinarily it may be assumed that at least one month will be

required after the work is begun and before actual driving can commence. As previously stated, this period may be very materially shortened by adopting the steam curing method when adequate means are available. A second serious drawback which limits the use of pre-cast piling, especially in congested districts, is the necessity of providing a very considerable area for a casting yard. In the case of the ordinary city building work it is seldom possible to set aside a sufficient area for this purpose, and therefore, if pre-cast piles are to be used in such instances, they must be made at another point and transported to the building site as required. A very ingenious and efficient

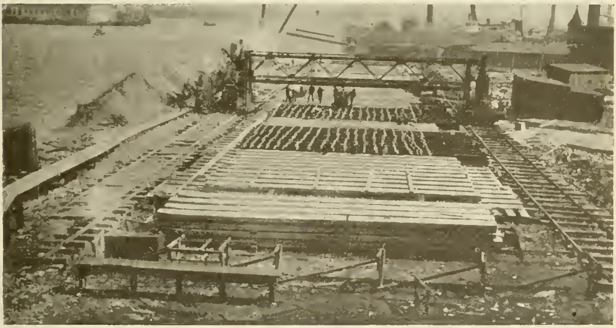

FIG. 22. CASTING YARD FOR CONCRETE PILES.

arrangement for reducing the space necessary for a casting yard is shown in Figs. 22 to 26. This system was devised and used by Mr. W. L. Miller, of Boston, in connection with a concrete-pile contract for a pier at Baltimore, Md. It will be noticed that the casting yard is long in proportion to its width and that a traveling bridge or crane spans the space occupied by the piles. Its power equipment is located at one end of the trussed frame, while the concrete mixing plant is integral with the opposite end. By means of a long shaft, the crane is propelled longitudinally of the casting yard so that it may readily cover any section. This traveling gantry was used to handle forms, reinforcement

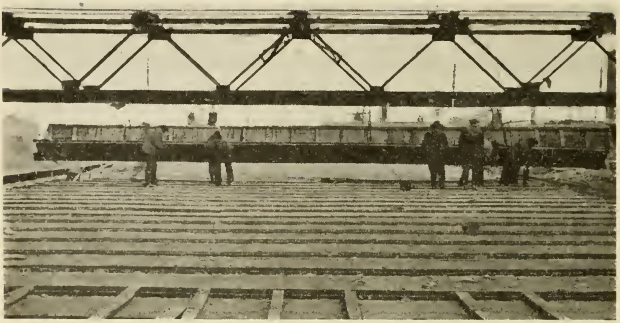

Fig. 23. Casting Yard for Concrete Piles.
(Handling forms.)

and concrete, and, what is of still more importance, it was utilized to nest the partially cured piles in tiers so as to economize in space.

Cast-in-place Piles.

Because of the unsuitability of pre-cast piles for the conditions oftentimes met with, there have been introduced a

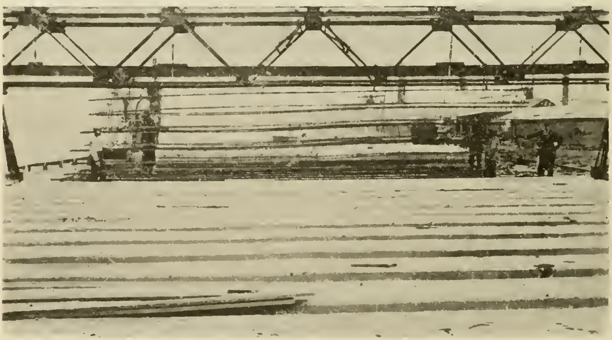

Fig. 24. Casting Yard for Concrete Piles.
(Handling reinforcements.)

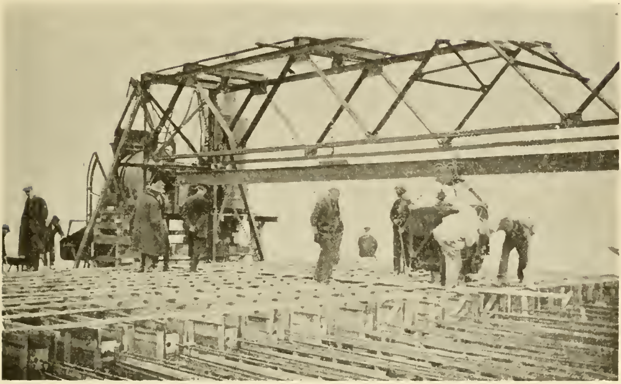

FIG. 25. CASTING YARD FOR CONCRETE PILES.
(Placing concrete.)

variety of ingenious methods for constructing concrete piles in place. This method obviates the necessity of a large casting yard and of the preliminary delay necessitated because of the initial curing period.

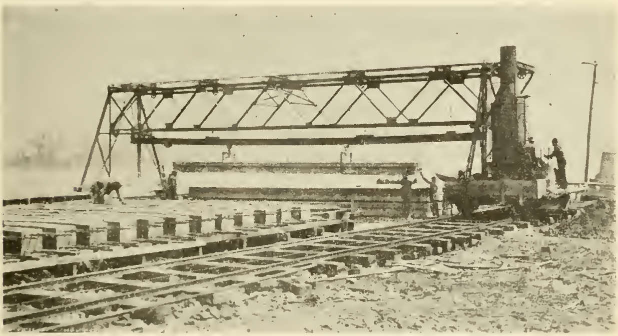

FIG. 26. CASTING YARD FOR CONCRETE PILES.
(Handling piles.)

The Raymond Pile.

The first pile of this type to be introduced in the United States was the " Raymond " pile, invented in 1896 by Mr. A. A. Raymond. This pile was first used in Chicago in 1901 (Fig. 27). It consists of a light, sheet metal tapered shell approximately 20 in. in diameter at the top and 6 in. at the bottom. This shell is fitted over a collapsible mandrel or core. The mandrel and shell are driven simultaneously by means of a heavily constructed pile-driving apparatus, and, when a satisfactory minimum penetration has been secured, the core is collapsed by an ingenious contrivance so that it may be withdrawn, leaving the shell to retain the surrounding earth while concrete is deposited within it.

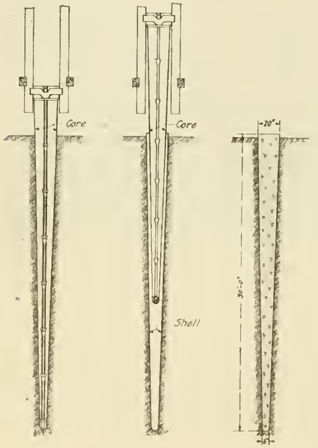

Fig. 27. The Raymond Pile.
(Built in place.)

The shell is usually built in 8-ft. lengths in such a manner that each succeeding section will lap the preceding one. The shells first used were of No. 18 or No. 20 gage, and it was frequently found that the reaction of the soil was sufficient to collapse this light metal wall after the core was withdrawn and before the concrete filling could be placed. In such cases it became necessary to drive additional shells inside the first until a combined strength sufficient to withhold the soil pressure was obtained. To obviate this difficulty, the type of shell was altered, some years ago, in a manner which permitted the use of No. 24 gage metal corrugated spirally, while in the corrugations was placed $\frac{1}{4}$-in. steel wire which not only resisted the collapsing pressure of the surrounding soil, but in addition served as a spiral hooping around the concrete.

The cores first used were made in three longitudinal sections which were expanded by means of a central longitudinal rod with connecting links. As this device was somewhat delicate for the rough usage accorded it, a more substantial type of core was later devised, consisting of two heavy semicircular longitudinal sections with a flat center strip between them containing wedge-shaped wings which forced the two halves of the core apart or drew them together as might be desired.

The advantages of this type of pile are found in the readiness with which its interior may be inspected before filling and the rapidity of progress due to the fact that the pile driver may proceed with the driving of a second pile while the first one is being filled with concrete. The concrete is protected by the spiral reinforcing against lateral strains during its period of setting. Reinforcing bars may be inserted before or during the concreting operation if desired, but this is seldom deemed necessary.

Among the objections urged against this type of pile are the following:

Because of its pronounced taper, a section of comparatively small area penetrates the firm soil upon which chief reliance is placed for supporting the load. This is especially objectionable when the pile is driven to rock or other very hard strata, and in almost every case the larger proportion of the surface area of the pile will rest in unreliable top material. It is also urged that there is some danger, while withdrawing the core, of the shells being started upward with it. Because of their pronounced taper, such an occurrence even though small in amount would destroy the frictional contact between the shell and ground. This does not seem to the writer a very probable occurrence or necessarily serious one, unless by chance the bottom section should be so withdrawn and thus remove the bearing at the tip. These piles have been driven up to 45 ft. in length.

The Simplex Pile.

In 1903 there was introduced in this country a built-in-place pile known as the "Simplex" pile (Fig. 28), the invention of Mr. Frank Shuman, of Philadelphia. It consisted at that time

of a pre-cast concrete point resembling somewhat in shape a large projectile approximately 16 in. in diameter, upon which rested a steel cylindrical tube or pipe 16 in. in diameter and of sufficient length and strength to permit driving it to the required depth. The point and tube were assembled in a vertical position and driven by an ordinary pile driver to refusal. Powerful pulling tackle was then applied to the top end of the tube, and, as concrete was deposited in the tube, it was gradually withdrawn so that the soft concrete might flow out against the surrounding soil and thus completely fill the space vacated by the tube. The pre-cast concrete point remained in the ground and formed the tip of the finally completed pile. More or less difficulty was experienced with the concrete points, due to breakage in driving and to the occasional tendency for the point to become driven into the tube and so wedged that it often was withdrawn with it. To overcome this difficulty, a new type of point was devised, which consisted of a conical-shaped steel point of hollow section, split longitudinally, each of its halves being hinged to the lower collar of the tube. With this apparatus the tube was centered in the pile-driver gins, the two halves of the point brought together so as to present a conical point to the ground, and the whole was driven as in the previous case. When final penetration was reached, the tube with this attached point was withdrawn a few feet, and by means of a heavy rammer or weight,

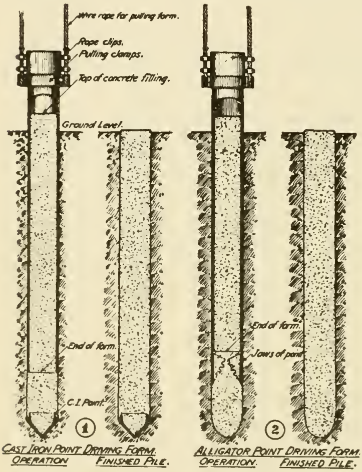

FIG. 28. THE SIMPLEX PILE.
(Built in place.)

which was lowered through the tube, the two halves of the conical point were forced apart and swung outward, leaving an open passage for the placing of the concrete. The tube was then withdrawn as in the previous case, as the concrete filling progressed. This so-called alligator point, while very ingenious and usually efficient, was found to have a serious drawback in that it was not always possible to obtain the full opening desired. If the halves of the cone, or either of them, failed to open fully, the sectional area was correspondingly contracted and there was danger while pulling the tube that a part of the concrete charge inside might be drawn upward with it, leaving a void which usually would be filled by the surrounding soil, thus destroying the integrity of the pile. In order to prevent such an occurrence, these piles are now driven with a loose cast-steel point which fulfills all of the functions of the two previous types and which is left permanently in place as a pile tip.

This pile has enjoyed a considerable degree of well-earned popularity in various sections of the country, and some notable installations are recorded to its credit. While its use has generally resulted satisfactorily, there have been instances of serious failure due to one or the other of two causes. First, the breaking of the continuity of the pile by occasionally withdrawing a part of the concrete as the tube is raised, and secondly by lateral distortion and displacement due to forces introduced in the soil during driving of subsequent piles. It will be readily seen that where concrete is deposited in a 16-in. tube, unless it is an easy-flowing mixture there is always the possibility of an arching action within the concrete mass which may cause it to adhere to the sides of the tube instead of flowing out and filling the space vacated by the tube during the process of withdrawal as intended. This difficulty can be and usually is provided against by means of careful watchfulness on the part of the foreman and inspector, or by the use of some telltale device which will indicate that the concrete is settling whenever the tube is being withdrawn. The second method of failure is not so easily provided against, nor can it be always readily detected. There appears now to be almost conclusive evidence that certain soils transmit their compression forces in a lateral direction for con-

siderable distances. The influence on surrounding objects, in the adjacent soil which may be subjected to these forces, was well illustrated a few years ago in Cleveland, where the driving of wooden piles for the Clark Avenue Viaduct produced such compressive stresses in the soil as completely to crush an 8-ft. brick sewer although the piles themselves did not come in contact with it. Similarly, during construction of the Fish Pier, at

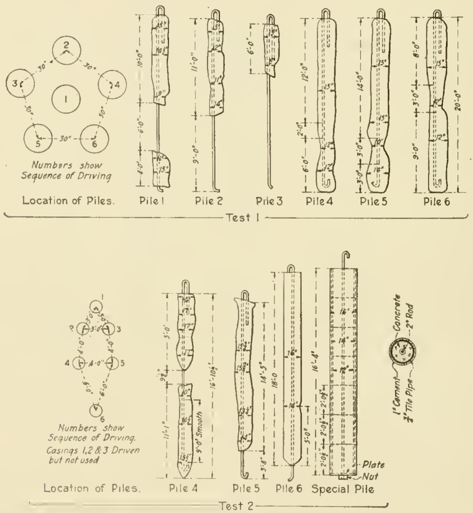

FIG. 29. DISTORTION OF BUILT-IN-PLACE PILES.

South Boston, Mass., a few years ago, the driving of foundation piles for buildings produced a lateral displacement of an exceptionally heavy stone retaining wall surrounding the pier and retaining the pier fill. It is obvious, where such conditions exist in the soil, that the driving of several piles of this type in a group may result in serious distortion and displacement of adjacent piles already driven. With a view to determining whether such distortion would be possible if the tubes were driven for all

of the piles in a cluster before any concrete was placed, Mr. Francis L. Pruyn, of New York, conducted a test about four years ago, wherein he drove six tubes 16 in. in diameter in a cluster, the individual tubes being 3 ft. on centers. After standing twenty-four hours they were filled with concrete and the tubes withdrawn in the usual way. Later on, when the concrete had attained sufficient strength, the piles were pulled out of the ground by means of heavy rods which had been imbedded in

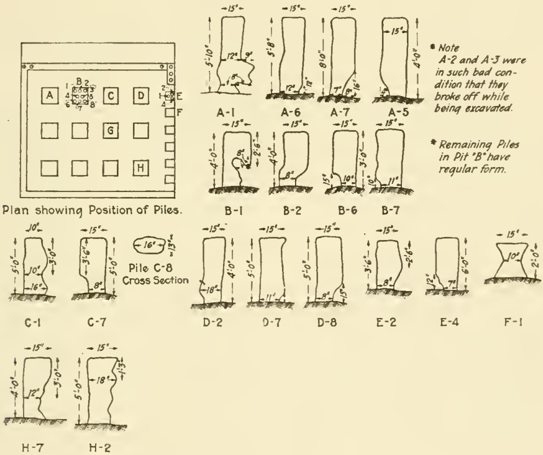

FIG. 30. DISTORTION OF BUILT-IN-PLACE PILES.

the concrete for that purpose, and the appearance of the several piles as then found is shown in Fig. 29. From this test Mr. Pruyn concluded that the pressure set up in the soil by the driving of the tube remained active even after a lapse of twenty-four hours. A similar result from that cause is shown in Fig. 30.

Fig. 31 illustrates the condition of some of these piles as disclosed by excavations made under the foundation of a building in Chicago a few years ago. The settlement of the building required that it should be underpinned to prevent further damage.

This was done by means of open circular wells sunk to hard bottom and located under the building walls. In the sinking of these wells many of the previous piles were uncovered, and their condition is clearly indicated in the illustration by the longitudinal elevations and frequent transverse cross-sections of the well excavations.

Notwithstanding these instances, it must be admitted that with the exception of a few such cases which have occasionally

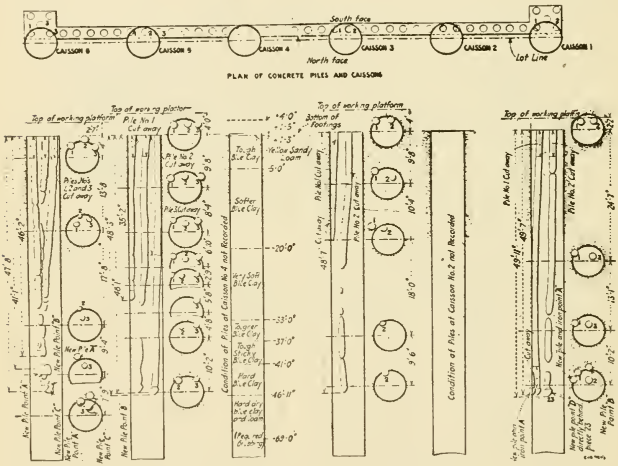

Fig. 31. Condition of Built-in-Place Piles Disclosed by Excavation.

come to light, this type of pile has proved uniformly successful and efficient in thousands of installations and under a great variety of conditions, and that test loads which have frequently been applied have usually indicated a remarkable sustaining power. Likewise piles of this type have been uncovered at various times by adjacent excavations and found, generally speaking, to be perfect in shape and condition. It seems likely, therefore, that various soils act differently in respect to the transmission of compressive forces, and it is also reasonable to

suppose that many deformed piles are successfully carrying considerable loads without any indication of their condition. In fact, the very compression of the soil which brings these conditions about may itself be a factor in furnishing adequate support exclusive of the piles, due to its resultant compactness. The rate of progress in the driving of "Simplex" piles is retarded somewhat by the fact that the pile driver must be utilized in pulling the tube during process of concreting, and thus work can proceed on only one pile at a time with a given machine. As the tube is withdrawn, its upper end is elevated so as to require the hoisting of the concrete before depositing.

Very severe strains are brought to bear upon the pile driver because of the enormous power required to start the tubes after they have been driven. Wear and tear on these machines is, consequently, very great, and it is not uncommon to lose a large amount of time on account of repairs to machine and apparatus.

The Pedestal Pile.

The "Pedestal" pile, Fig. 32, was invented in 1909 by Mr. Hunley Abbott, and combines the essential features of the "Simplex" pile with somewhat distinctively individual qualities. Instead of adopting a point on the tube, the "Pedestal" pile employs a solid plunger which occupies the interior of the tube and projects a few feet below the bottom thereof. This plunger is pointed at the lower tip and its top end, and is provided with a collar which rests upon the upper edge of the 16-in. tube. The point, tube and plunger are driven as a unit by an ordinary pile driver. The plunger is then withdrawn, leaving the open-ended tube in the ground with a recess in the soil below. In this recess, concrete is deposited and the plunger is again used, this time as a rammer to force the concrete against and into the surrounding soil with such force that a bulb-shaped footing is formed upon which the body of the pile rests. The tube is withdrawn and concrete deposited as in the case of the "Simplex" pile, the result being a 16-in. cylindrical column resting upon an enlarged base. This type of pile obviously possesses all the advantages of the "Simplex" pile and in addition an

increased supporting power due to the spread footing. In other words, if the "Simplex" type of pile is employed to support a given load, the addition of the bulb-shaped footing will afford that much additional security against settlements. On the other hand, the character, shape and dimensions of the bulb which is formed are matters of speculation and not of certainty. In some soils it is doubtful if a bulb of any appreciable size is formed. In other cases, if the resistance of the soil for any reason is not uniform, the shape of the bulb will follow the direction of least resistance. If the pile is properly driven

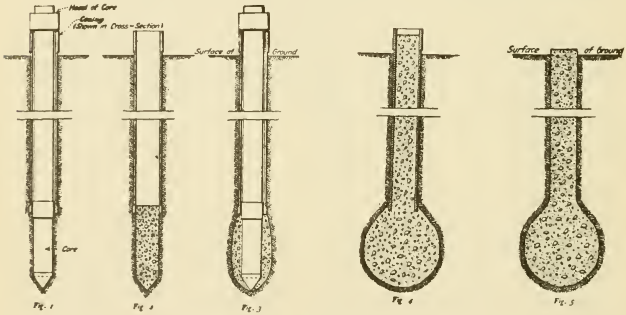

FIG. 32. PEDESTAL PILE.
(Built in place.)

and the stem retains its integrity, the bulb footing is, so far as serving any useful purpose, superfluous. It must be conceded, however, that, in some classes of soft soils which are of a depth in excess of the ordinary available pile length, this bulb footing may be very valuable as an aid in safely distributing the load. This pile naturally possesses all of the disadvantages of the "Simplex" type, especially that due to possible distortion and displacement of its stem.

A group of "Pedestal" piles driven at Long Island City, N. Y., was uncovered by direction of the Building Department, to permit an examination to be made of their condition. This was found to be excellent in every respect. It is reported that

the material in which they were constructed consisted of rubbish fill, muck and sand, the piles being 20 ft. long. It is apparent in this instance, at least, that the rubbish and muck were sufficiently compressible to permit of being displaced laterally without setting up pronounced elastic forces in the soil.

Piles of the "Simplex" and "Pedestal" type cannot be used in semi-fluid material, or in situations where a portion of the length must be constructed in water, because the concrete filling would escape laterally when the tube was withdrawn. It is possible, however, by a slight modification of the method, to meet these conditions when necessary. The heavy driving tube is put down in the usual manner and, after some concrete has been deposited, a light steel shell may be inserted in the tube, filled with concrete and left permanently in place to retain the fresh concrete after the driving tube has been withdrawn.

Peerless Piles.

Another type of built-in-place pile which has recently been introduced is known as the "Peerless" pile, Fig. 33. Short lengths of thin reinforced concrete hollow shells are superimposed upon one another to the approximate length of pile desired. These shells are assembled upon a cast-steel point or shoe, and a heavy plunger or follower is inserted through the hollow interior so as to rest upon this steel shoe. On the upper portion of this plunger is an adjustable collar which overlaps and bears upon the top section of the concrete shell. This combination of shells, point and plunger is then driven to refusal by means of an ordinary heavy

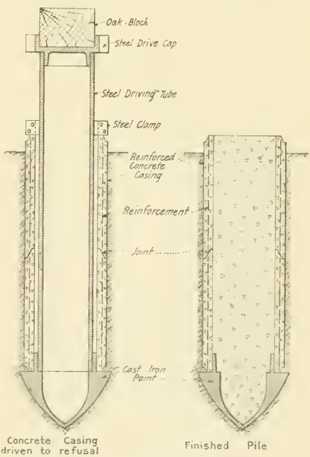

FIG. 33. PEERLESS PILE.
(Built in place.)

pile driver. It will be seen that the steel point receives the direct driving impact which is transmitted by the plunger and that the concrete shells are merely followed down without being called upon to take any strains other than those necessary to overcome their own surface friction against the surrounding soil. The maximum section of the cast-steel shoe is of a slightly larger diameter than that of the concrete shells, so that the former produces all of the displacement in the soil, while the opening made by it, being slightly larger than the shell, minimizes the amount of surface friction against the latter. When the shells have been thus driven, the plunger is withdrawn and the hollow interior of the shells filled with concrete. The reinforced concrete shells serve the purpose of a driving tube and also eventually form a part of the pile itself. This type of pile has not been used to an extent which would warrant an expression as to its relative advantages or disadvantages. It would seem that in the case of a water-bearing soil, trouble might occur from infiltration of ground water through the several joints between successive shells. There would appear to be no good reason, however, why these joints should not be made reasonably water tight by the insertion of some form of water-tight gasket. It also seems likely that the cost of preparing the shells might render such piles uneconomical in comparison with other available types. The general principles utilized, however, appear to offer some advantages over other built-in-place types. There is no lost time in pulling shells, neither is the concrete required to be elevated during the process of filling, as in the case of the two previously mentioned types. It is possible to inspect the interior at all times during the filling, and ample strength is provided by the shells against distortion due to lateral pressure. Generally speaking, it will also be possible to construct piles of a greater depth by this method than with the "Simplex" or "Pedestal" types, in which the difficulty of withdrawing the tubes limits the possible length of the pile to not over 50 ft. In the case of the "Peerless" pile, it is only necessary to use a plunger of sufficient length and to build up sections of shell to the extent required.

Tubular Piles.

Tubular piles have been used for a great many years for various purposes, but their use did not become common until fifteen or twenty years ago, when they were introduced to a considerable extent for the solving of some foundation problems in the city of New York. This use seems to have originated in the patented method adopted by Breuchaud in 1896, wherein he utilized them in the underpinning of buildings in and about New York City. The process consisted of cutting a narrow, vertical breach in the masonry of the building wall and inserting in this slot a short section of 12-in. steel tube, which was then forced vertically into the ground by means of hydraulic jacks of 60 to 100 tons capacity, reacting against short horizontal girders built in the masonry above them. Successive sections of double strength 12-in. pipe were coupled together so as to extend the length of tube until it finally reached hard bottom. The earth was then washed from the interior of the tube and concrete deposited until the pipe was filled. Bearing plates were adjusted at the top of the pipe and the load of the building transferred to them. The usual progress made by this method was about one foot per hour.

Later on, the use of "Tubular" piles became common in the construction of foundations for new buildings. In general, the method has been to drive these piles in sections sometimes to a total depth exceeding 100 ft., or until they reached ledge, and to insert therein steel rods which were incased in the concrete filling of the tube and rested at their lower extremity upon the ledge. It has been customary in New York City, where this method has been extensively employed, to figure these piles as columns fully supported laterally, with an allowance of 500 lbs. per sq. in. on the concrete section and 6 000 per sq. in. on the cross-sectional area of steel, including that of the pipe itself. The steel rods used for this purpose are usually 2 to $2\frac{1}{2}$ in. in diameter, and as many as 117 tons have been supported upon a single 12-in. tubular pile 70 ft. in length. The tube employed for this purpose is usually 12 in. in diameter and $\frac{3}{8}$ in. in thickness. In order to transmit the enormous load carried, it is necessary to square carefully the abutting ends of successive

sections of pipe and reinforcing rods, and, in order to avoid excessive external friction during driving, interior sleeves are adopted (Fig. 34). Heavy pneumatic hammers are usually employed in the driving of the piles, being handled by construction derricks. When the tube has finally reached ledge, its interior is thoroughly washed out by means of a strong water jet, but frequently in later practice by a stream of high-pressure compressed air which often proves more efficient in removing all soil from the interior of the pipe.

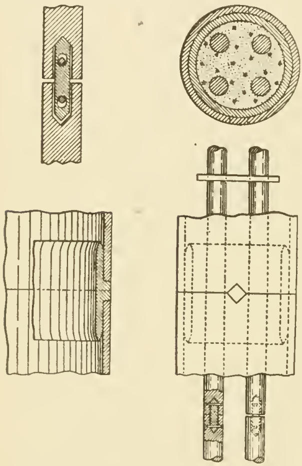

Fig. 34. Splices in Steel Tubes and Reinforcing Rods for Tubular Piles.

It is sometimes urged against the use of "Tubular" piles, or other types having a permanent steel casing, that the steel pipe will ultimately be destroyed by rust. The writer has been interested in this subject for a great many years, and has reached the conclusion, after observing the condition of hundreds of specimens of steel and iron embedded in the soil for long periods, that there need be no apprehension of trouble from this source. The oxygen needed for the rusting process is to a very considerable extent excluded from the soil, and even though there be a sufficient amount to produce some oxidation, the first layer of rust which forms being prevented by the surrounding earth from dropping off, serves as a protection to the remainder of the metal against any progressive rusting action. It will almost invariably be found, where wrought, steel or cast iron is uncovered after several years' burial in the ground, that the outer layers of rust have amalgamated with the adjacent soil and have formed what is equivalent to a rust joint which thoroughly protects the body of the metal.

Compressol Piles.

The "Compressol" pile, Fig. 35, is of French origin and has enjoyed a considerable use on the European continent. It has been little used in this country, however, although it was introduced in 1913 at Perth Amboy, N. J., in the construction of some building foundation work at that place. The process consisted in elevating a massive conical-shaped weight, 8 ft.

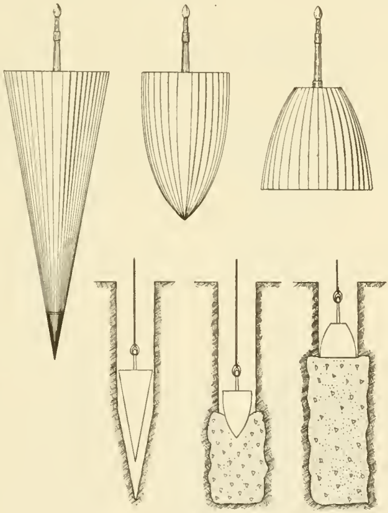

Fig. 35. Compressol Pile.
(Built in place.)

long and 3 ft. in diameter, weighing $2\frac{1}{2}$ tons, with its point suspended downward. This weight is then dropped so as to penetrate the ground at the point where the footing is to be constructed. Successive blows by this instrument eventually produced a cavity which extends to the desired depth or bearing stratum. If the material constituting the particular soil is

water bearing, clay and cinders are dumped into the cavity and rammed by the succeeding blows into the surrounding soil so as to render it impervious. When the desired depth has been reached, concrete is deposited in the bottom of the cavity and by means of a somewhat more rounded tool with an olive-shaped point, weighing about 2 tons and similarly used, the concrete is expanded laterally into the surrounding soil, giving a spread to the footing. Eventually the entire cavity is filled in this manner, leaving an irregular-shaped column of concrete in the soil. Large rocks are often used to consolidate the concrete mass and to assist in displacing the surrounding soil. While this process is apparently a simple and economical one, it suggests many elements of uncertainty as to final dimensions and conditions of the resulting pile. Nevertheless it may be well suited for many temporary purposes where the element of cheapness is paramount to that of known efficiency.

Wilhelmi Pile.

Another type of pile little heard of in this country is the "Wilhelmi" pile, Fig. 36. This pile is of French invention

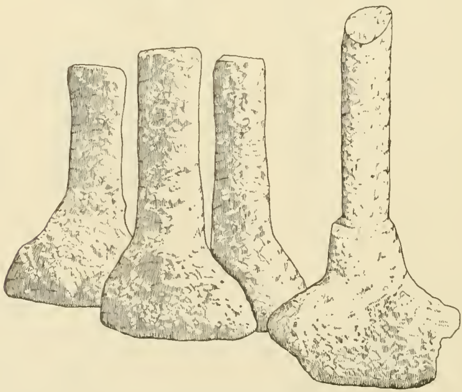

FIG. 36. WILHELMI PILE.
(Built in place.)

and resembles very closely the "Pedestal" pile in final result, except that the bulb chamber is formed by exploding a charge of dynamite in the lower portion after the tube has been driven.

The Caisson Pile.

The "Caisson" pile, Fig. 37, appears to have originated in Chicago in the year 1893. In reality it can hardly be classed as a pile, but resembles more closely an ordinary pier footing except that the excavation is made to the exact dimensions of the pier, and concrete forms, therefore, are not required. The excavation is circular in cross-section and of sufficient area to support the pier load in compression. This circular excavation is carried down to good bottom, the walls of the excavation being lined in short sections by wooden staves held in place by interior rings. When satisfactory bottom is reached, the excavation is enlarged in the shape of a frustum of a cone,

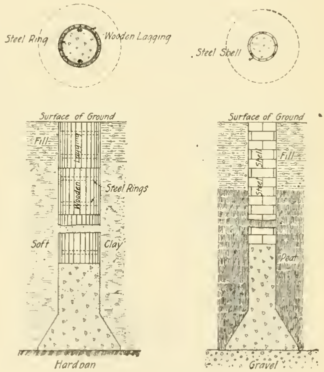

FIG. 37. CAISSON PILE.
(Built in place.)

so that the load may be safely distributed over a sufficient area. The excavation is carried on by the pick-and-shovel method, small-sized buckets being used to elevate the earth as it is loosened. When the excavation is completed, the bottom may be inspected and concrete then deposited, first filling the footing chamber and later the circular shaft. The sections of wooden lining, together with their supporting rings, are removed as the concrete filling progresses, so that the final construction results in a circular concrete column resting upon a spread footing and capable of supporting safely a total pier load of an amount depending upon the dimensions of the shaft and footing. It is possible for a man to excavate within the limits of a 3-ft. diameter shaft.

This shaft when filled with concrete is capable of supporting a 250-ton load, using a unit compressive value on the concrete of 500 lbs. per sq. in. If loads in excess of this amount are to be applied, the diameter of the circular excavation must be increased accordingly. The area of the base of the enlarged footing must be made sufficiently greater than that of the shaft to distribute the total load safely upon the supporting soil. This method has been used in the soft Chicago clays to depths of 80 ft. or more. Oftentimes it becomes necessary, in passing through water-bearing sands and other unstable soils, to use a light vertical shield which retains the shape of the hole while the wooden lining is assembled inside of its protecting shell. In some instances it becomes necessary to adopt the pneumatic process in the sinking of these piles, in order to penetrate troublesome material. The writer has had occasion to use this system to a considerable extent in the vicinity of Boston, Mass. On account of the prevalence of water-bearing strata in that district, the temporary lining adopted has generally been of steel cylinders, either driven in lengths or made sectional and bolted together.

Wherever considerable loads are to be supported at given points, the "Caisson" pile will usually be more economical than equivalent clusters of individual concrete piles. Generally speaking, however, this does not apply to loads under one hundred tons. It is not possible to construct "Caisson" piles under all conditions, and, therefore, clusters of individual piles may frequently be necessary in any event. Since the "Caisson" pile usually rests directly on top of the bearing soil stratum, its length is materially less than that of driven piles for the same location, which necessarily must enter a sufficient distance into the bearing soil to develop the necessary frictional resistance.

Combination Piles.

Various combinations of concrete and wood piles and of pre-cast and built-in-place piles have been used under special circumstances. Tubes driven by the "Simplex" method are sometimes utilized to receive pre-cast piles which are merely

inserted inside the tube after the latter has been driven and a small amount of concrete deposited above the point. The pre-cast pile is forced into this fresh concrete, and grout is poured into the space between the pile and the tube. The tube is then withdrawn in the usual manner. This arrangement avoids the necessity of subjecting the pre-cast pile to any driving strains and prevents any distortion of the pile when the tube is pulled.

An interesting instance of combining the two systems is reported in the case of the 25-in. diameter concrete piles for the Atlantic City Music Hall Pier. These piles were cast with bulb-shaped footings $3\frac{1}{2}$ ft. in diameter, and were sunk into place through the sand by the jetting process. In order to avoid the handling of such extremely heavy piles, only the bulbs and a short length of the stem were pre-cast, the reinforcing rods, however, projecting for their full length. A light steel shell of 25-in. diameter surrounding the reinforcing rods was attached to the pre-cast portion of the pile and the joint with it made water tight. After the footing with the attached shell had been jetted into place, the remainder of the pile was cast in place by merely filling the shell.

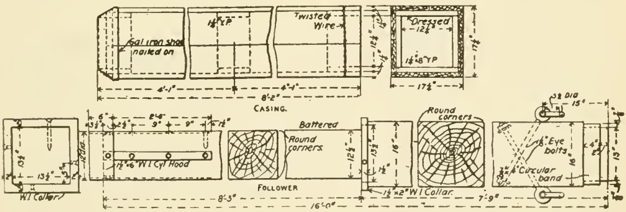

Fig. 38. Form and Box Follower for Combination Wood and Concrete Pile.

In the construction of the Delaware, Lackawanna & Western Hoboken Terminal, in 1905, the station platforms were supported upon wooden piles whose tops were driven 8 ft. below grade by the following means. (Fig. 38.) A square box consisting of 2-in. planks 8 ft. long was constructed upon the head of

each pile. A wooden follower was inserted through this square box and rested upon the head of the pile. By means of a collar near the top of the follower, the square box was driven into the ground with the pile. The follower was then withdrawn and the box filled with concrete, thus insuring safety against decay of the wooden pile heads.

In another instance, hollow steel pipes surrounded wooden pile heads and permitted the entrance of a follower so that the pile head might be successfully driven below the water level, after which concrete was deposited inside of the pipes.

Wooden piles for wharves and piers have often been driven in the usual manner, and the top portion standing in the water surrounded with concrete shells, the intermediate space being filled with grout or concrete.

The " Ripley " pile, so called, consists of a wooden pile wrapped with a metal mesh and concrete so as to form a concrete pile with a wooden core.

Some simple expedients are frequently resorted to in special cases where economical considerations preclude the adoption of more elaborate or expensive types. For example, common auger borings up to 15 in. in diameter have been successfully made in gumbo soils and the resulting hole filled with concrete, thus forming a reasonably satisfactory type of concrete pile for moderate loads. In another instance, grouting the underlying soil was resorted to, working from the bottom upward, thus consolidating a column of otherwise unsatisfactory soil immediately under the load.

Still another method of securing concrete pile foundations has been to build and jet the piles simultaneously, using very light sheet-steel shell sections of No. 20 gage, telescoped together similar to ordinary stove piping, a $1\frac{1}{2}$-in. jet pipe being introduced in the center and the shell filled with concrete. By applying the jet pressure, the soil is washed away in advance of the pile, which drops into the cavity from its own weight. The writer has sunk piles to a depth of 80 ft. by this process, in fine sand and silt.

Selection of Type of Pile.

The determination of the particular type of concrete pile which should be adopted for a given case usually presents more or less difficulty. The problem may generally be solved, however, by a careful consideration of all the factors physical and economical which enter into the situation.

In the construction of wharves, docks and other works of a class which requires that a portion at least of the pile length shall stand in or above a body of water, the choice ordinarily will be limited to the pre-cast type of pile (Figs. 39, 40, 41 and 42). In a congested locality in the heart of a busy city, on the other hand, where construction space is not readily available, the built-in-place type of pile will be more likely to answer the requirements of the case.

Similarly, if it is necessary, because of important considerations, to commence construction operations immediately, and especially if there be no satisfactory means available for curing the piles by steam, it will usually be advisable to abandon the pre-cast pile suggestion because of the prohibitive length of time which must elapse after their manufacture and before they can be handled and driven.

The use of the pre-cast pile is often undesirable when there is not readily available a sufficient source of water supply to furnish an adequate volume for the jetting process. The amount of water used in jetting piles is, in the aggregate, considerable. From 100 to 200 gals. per minute is probably not an excessive estimate of the quantity of jet water required in sinking piles by this method, and, where such volumes of water are not at hand, economical considerations may suggest the adoption of built-in-place piles in preference to those which require jetting.

Sometimes it is necessary to drive only a comparatively small number of concrete piles for a given purpose, in which case the expense of transporting, erecting and removing the extremely heavy driving apparatus necessarily employed with built-in-place piles will render the cost of such a small group prohibitive. In such cases pre-cast piles may be driven or jetted with the aid of the construction derrick, utilizing a steam hammer suspended from the derrick boom, or a small

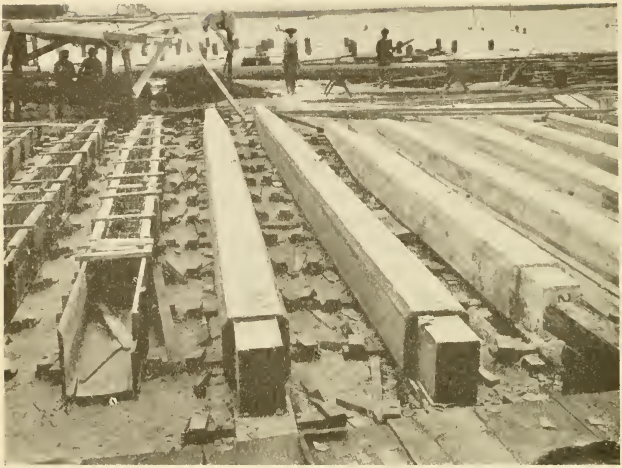

FIG. 39. PRE-CAST PILES FOR WHARF.

FIG. 40. WHARF CONSTRUCTION ON CONCRETE PILES.

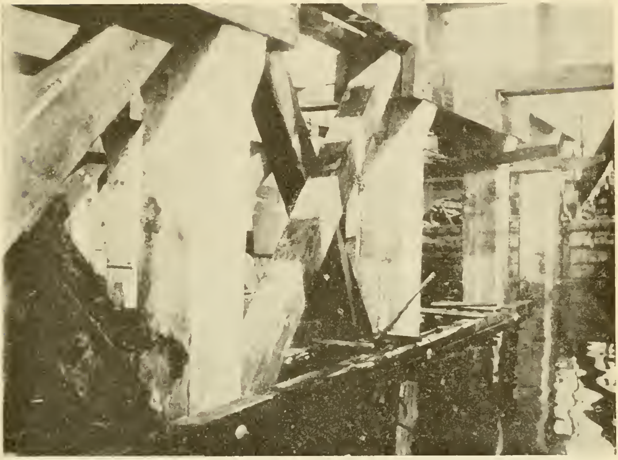

FIG. 41. WHARF CONSTRUCTION AT CHARLESTON, S. C.

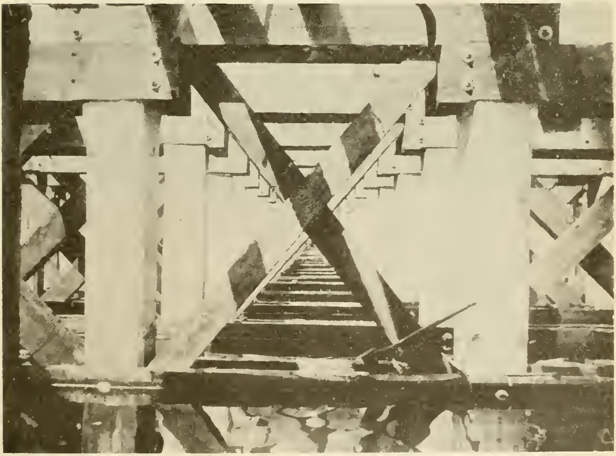

FIG. 42. WHARF CONSTRUCTION AT CHARLESTON, S. C.

timber driving frame (Fig. 43) may be employed. Where there are but a few piles required for a given installation, the writer has frequently recommended the use of light tubes in the form of second-hand wrought-iron pipe driven into the ground by some simple apparatus, after which they may be washed out and filled with concrete, leaving the wrought-iron shell as a component part of the pile. This, of course, is merely an adaptation of the tubular pile previously described.

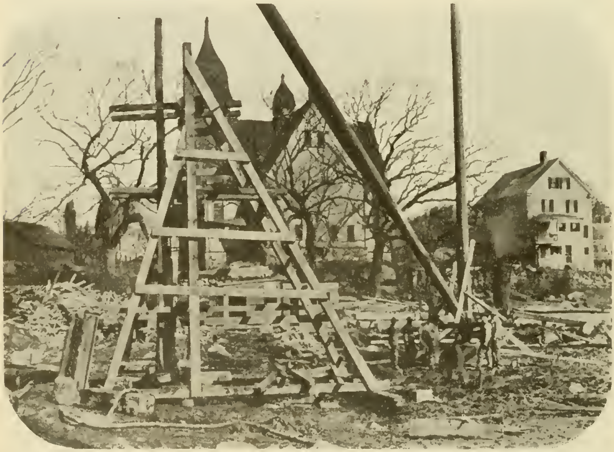

Fig. 43. Pile being Driven with Aid of Construction Derrick and Timber-Driving Frame.

If it is deemed desirable to adopt the pre-cast type of pile, the particular conditions surrounding the work may suggest the adoption of one or another of the patented types of pre-cast piles, although in general any type of pre-cast pile can successfully be driven if proper facilities are available. If the material through which the pile is to be driven is of a nature which renders jetting more or less ineffective, recourse must be had to long-continued hard driving. In such a case, a pile of the " Cum-

mings" type probably offers as good a solution as can be found, especially for long lengths of pile. The "Giant" pile also is obviously well suited for such a condition, although it seems probable that its use must be limited to lengths not exceeding 25 to 30 ft. In situations where the use of the hammer is difficult, expensive or inconvenient, the "Bignall" type of pile may offer a solution, relying upon the jetting process only. In any of these cases, an unpatented type of pile may be designed and driven with the use of proper cushion caps and hammers so that final results may be equally satisfactory. The question involved, therefore, is merely one of relative economy.

With regard to the several types of built-in-place piles, it seems reasonably clear that those types which leave their shells permanently in place, such as the "Raymond," "Peerless" and "Tubular" piles, offer a somewhat better guarantee of the final and continued integrity of the completed pile. The use of the "Raymond" pile, however, should probably be limited, as previously suggested, to those cases in which a substantial portion of the length of pile will rest in firm soil in order that too great a proportion of the load will not have to be carried on the small sectional area near the point. These three types of piles may also be driven to greater depths than other types of built-in-place piles for the reason that there is no tube to be withdrawn, a process which requires enormously powerful tackle and lifting apparatus, especially when the length of tube is great.

In the great majority of cases, however, built-in-place piles of the "Simplex" and "Pedestal" type may be used with perfect safety and oftentimes with decided economy. It seems probable to the writer that in soils which are definitely and permanently compressible, such as peat, silt and rubbish filling, there is little likelihood of a subsequent reaction of a nature which will cause damage to the piles. On the other hand, it appears reasonably conclusive that some of the clays, sands and gravels are decidedly elastic in character under certain conditions, and that the resultant action due to driving piles into them is one of displacement laterally rather than of simple compression. This displacement apparently sets up elastic

forces of considerable amounts which react against the soft concrete after the protecting tube is withdrawn, tending greatly to displace and deform the concrete sections and also to disturb the adjacent piles, previously driven, because of the lateral motion imparted to the surrounding soil. When this type of pile is used in soil which is not known to be positively compressible, it will be well to avoid driving successive piles within six feet of one another. This requirement undoubtedly places a considerable economic burden upon the driving contractor because of the greater amount of machine moving required. Nevertheless, unless actual inspection may be had of test piles driven at closer intervals and indicating an entire absence of damage by deformation, the owner is not justified in sanctioning the more economical procedure.

Where heavy concentrated pier loads are to be carried on piles, it will usually be well to give consideration to the possible adoption of the "Caisson" pile method. In order that this type should be applicable to a given case, the soil at the base must be of a nature which will permit chambering in the shape of a frustum of a cone, and this implies a considerable degree of firmness and cohesion between the particles constituting the soil. There will usually be no difficulty in chambering enlarged footings in dry clay, stiff mud or peat. This method will obviously be impractible in a loose soil such as sand, gravel or semi-fluid mud. This type of pile will usually not be economical in comparison with other types for loads less than one hundred tons each.

It is probable that the combination wood and concrete pile might more often be used than is customary. Where the conditions impose only a very moderate load upon each pile, and when large numbers of piles are required in the aggregate, a very considerable economy will result if the wooden pile is used in conjunction with a hollow pipe or box follower, so as to permit the head of the wooden pile to be driven below ground water level while the follower portion is filled with concrete.

MEMOIR OF DECEASED MEMBER.

LORENZO GORDON MOULTON.*

Lorenzo Gordon Moulton was born in Beverly on February 7, 1848, being the eldest son of Eben H. and Irene (Conant) Moulton. He was a direct descendant of the early New England settlers, descending on his father's side from Robert Moulton, who was sent to Salem from England by the Home Company in 1629, with orders to begin shipbuilding, and on his mother's side from Roger Conant, who came to New England in 1623.

He attended the Beverly public schools, usually leading his class, and graduated from the High School at the age of fifteen.

Two years later he left home to learn the pattern maker's trade at Boston, his first job being with Spaulding and Coffin. Later he went to New Jersey, where he worked a year, on his way back to Boston making a walking tour of the Pennsylvania iron regions and trying to acquaint himself with every phase of the iron business.

In '73 he entered the employ of the G. W. and F. Smith Company, with which he remained, with the exception of a year or two, up to 1915, at first serving as foreman of the pattern shop, then as mechanical engineer.

Mr. Moulton was of a studious nature and found time, in addition to the study necessary for his profession, for wide reading on many other subjects. He was a deep student of Latin, French and German, and was a botanist of no mean order. His fund of general information was remarkably large, it being proverbial among his associates that about doubtful questions "Moulton would know." As a mathematician he was rapid and accurate, and he was particularly successful in solving the intricate problems connected with the alteration and reconstruc-

* Memoir prepared by L. L. Street.

tion of buildings. Many visible examples of his skill along these lines may be seen in Boston and are well known to his associates.

He became a member of the Boston Society of Civil Engineers on April 16, 1913. He was a member of the Masonic fraternity, being affiliated with Liberty Lodge of Beverly. He was married and left one daughter, now living in Boston.

He died on June 9, 1915.

Vol. IV MAY, 1917 No. 5

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

ADDRESS AT THE ANNUAL MEETING.

(March 21, 1917.)

By Richard A. Hale, President, Boston Society of Civil Engineers.

In the annual address which the President, according to the by-laws, shall deliver at the close of his administration, it is desirable to consider some of the present conditions and the problems that are to be met in the future. The high ideals of the Society in regard to engineering ethics have been maintained as in the past. The personnel of various state commissions more frequently includes the trained engineer than in the past, and his technical training, in considering problems, renders him of especial value to other members whose training has been along other lines.

A good business judgment is necessary in connection with the technical training, to determine whether, from a financial point of view, many undertakings are desirable. The coöperation of this Society is appreciated by various commissions, who recognize that technical skill and thought is of great assistance in carrying out the lines of work in which they are interested. This coöperation with the state should be the duty of engineers as far as possible; and the Legislative Committee of the Boston Society of Civil Engineers, which has appeared to discuss various bills which were presented to the legislature and in which engineers and municipalities in general were interested, has shown its usefulness in various ways.

The subject of expert testimony should always receive careful consideration. In cases submitted to the Courts for decisions, the testimony of expert engineers on the opposing sides is often conflicting and bewildering to the Court, and shows wide variations in statements presented. This may be due to differences in the points of view which the experts take of the case, each looking at it at a different angle from his brother expert; and there are oftentimes as many angles as experts. It has been suggested by one of our past presidents, in a well-written paper on Expert Testimony, that the German Court method be adopted. This provides that the expert be appointed and remunerated by the Court, in order to remove any tendency to favor the side on which he is retained. It does not seem feasible to adopt this method without modifications. Differences of opinion exist among those who have made careful studies of the cases with which they are connected, and they may be honest in their belief along the lines in which they testify. The chief problem, often perplexing to the Court, is to sift the truth from the various presentations. At the present time there does not appear to be as great a tendency as formerly to bring cases involving expert witnesses and scientific testimony into the courts, but rather to meet in conferences to arrange settlements without resorting to long and expensive trials. The engineer can fill an important part in these conferences of counsel, and aid materially in arriving at logical conclusions. The business judgment of the engineer, in connection with his scientific training, makes a combination that is desirable in such matters.

Cases involving technical matters are now referred more frequently than formerly to engineers as arbitrators, with much saving of time and expense compared to what would be involved in the natural course of court procedure. As an illustration, a case may be cited which occurred some years ago in a neighboring state, involving the interpretation and division of water rights among seven or eight owners. A suit was brought by one of the parties against the others. The case involved many engineering features which were matters of fact. One of the former members of this Society (now deceased) and the writer

were retained by opposing parties. As it appeared a great waste of time and expense to work up in duplicate the detail of the case, the writer suggested that, with the consent of counsel, a joint report should be made on agreed facts. This method appealed to all parties to such an extent that the Court appointed a commission, consisting of the two engineers and a lawyer, the latter to advise on legal points. With the writer as chairman, hearings were held and testimony taken regarding facts which it was desired to present by counsel, and a joint report on the technical details was finally made and approved by the Court, and all parties were satisfied. It was a grim satisfaction to the writer as a commissioner to request the counsel to make the examination of witnesses more brief, as the testimony presented was of no great value to the Court.

In a case now in progress before an auditor, the engineers on both sides were authorized to make a joint report on many facts which would have been bewildering to present in any other way, as they were extremely voluminous and would have become hopelessly involved in cross-examination. Under this agreement, many extensive tables of figures, computations, etc., were presented in a clear and logical manner.

An engineer at times meets counselors who are so anxious to win their cases that, rather than seek the truth, they devote themselves to obtaining evidence to suit their views of the case. What they are seeking is manufactured evidence. Fortunately, such lawyers are very rare, and during the writer's experience in expert cases, extending over the last thirty-five years, he has formed many friendly and enjoyable acquaintances among the members of the legal profession.

In the preparation of cases, the engineer should follow a logical, clearly defined plan; should be concise in his statements, and give clear illustrations of what he is attempting to show. Such methods are appreciated by the Court, and more weight is given to testimony of such character than in a poorly prepared case.

I have probably told you what many of you already knew, but it may suggest some thoughts to the younger members of the Society.

At the present time, when Preparedness and Efficiency are the watchwords of the hour, the thought of the engineer naturally turns to those matters in which greater efficiency can be attained, and among those more apparent is conservation of the natural resources, particularly water power. With the high cost of fuel, attention is naturally attracted towards the utilization of water power to the best advantage and greatest economy. When one sees the quantity of flood water wasting in the spring, and considers how much assistance it would render in the summer, in periods of low flow, one feels that conservation of resources should receive greater attention.

This matter, as is well known, has been studied in this state for several years past, and interesting records of the flow of streams are being compiled and studies are being made for reservoirs at the head waters. The subject offers a wide field for investigation by engineers and requires careful consideration. Whether the results attained are commensurate with the expense incurred, and how the expense is to be apportioned, are difficult problems.

In the use of storage reservoirs at the sources of the streams, when developing water powers and acquiring riparian rights, building dams and necessary regulating gates, a large expense may be incurred in proportion to the benefits gained. These problems should be considered so as to give to the water-power users along the stream definite information as to the amount of water which will be delivered from these reservoirs at periods when most necessary to all parties. The distances from the reservoirs to the dam at which the water will be used, and whether the use by parties along the stream is for twenty-four hours or for ten hours per day, are important in determining the value of the power. The value of the water for manufacturing purposes is much greater than for power, which can be replaced. The use of the water for bleaching, dyeing, etc., may be of such importance as to warrant a large outlay in reservoirs.

This is one of the problems that presents itself to the engineer at this time, when efficiency is desirable. The results of the large reservoirs, constructed by the National Government at the head waters of some of our large rivers, to aid navigation,

have not been what were hoped, but they have proved of great benefit to water-power users lower down on the stream. In all cases there is difficulty in correctly forecasting wet or dry seasons.

The entire field opens up an opportunity for the engineer to show his skill in these problems. The careful study that is being made on conservation in this state is of great value in connection with the measurements of the flow of streams. Our adjoining states are taking up the subject, and appropriations are being made for studies of conservation and stream flow.

With the heavy freight congestion of the railroads, some method of relief is sought, and the possibility of water transportation on the Connecticut and Merrimack rivers and by proposed canals is being considered; these problems give opportunities for the transportation engineer to investigate the economic conditions and whether the results to be obtained are commensurate with the expense.

In this connection the subject of inland waterways is prominent, and this afternoon we are to have the pleasure of listening to a description of the development of one of the finest systems of inland waterways in the country and its effect on rail transportation.

In our own state an investigation was made about eight years ago by the writer for the Massachusetts State Improvement Commission, regarding the possibility of reviving various waterways that had been projected, and in some cases developed, during past years. The situations, both topographically and regarding conditions of environment, were essentially at variance with those in New York state, and the results of the investigation were not specially favorable. As an illustration: In the study of the old Middlesex Canal, from Lowell to Boston, it was found that although the original bed of the canal was available at portions of its location, other portions had been built upon, and the terminals in Boston were occupied by valuable property. The supply of water required for lockage purposes, to be taken from the Concord River, was a serious matter, as the active season of navigation would occur during the summer months when the flow of the stream was lowest, and the water was of the greatest importance to manufacturers located on the

lower portion of the stream. Its greatest value is for general manufacturing uses in dye houses, bleacheries, etc., for condensing, etc., being greater than its value for power, for which substitution could be made. When the Boston & Lowell Railroad was started, it was found that rail competition could not be met, and the Canal Company finally went out of business. The length of the route had some effect on the situation.

Another projected canal was proposed in 1825, by Col. Loammi F. Baldwin, from Boston across the state to the Connecticut River, and thence to the Hudson River by way of a tunnel through Hoosac Mountain. At the time of the state report, in 1909, it was found that the damages to the various water powers located along the proposed route, on account of diversion of water for lockage, would reach an excessive amount. It was also found that many ponds, rivers, etc., from which a water supply for lockage was expected, were being utilized for domestic supplies and were not available for a canal. Various conditions of this kind showed the water route to be unfeasible.

Similar conditions existed along the Blackstone River, where the Worcester and Blackstone Canal was located, and where a railroad was eventually built, and freight went by rail instead of by water. The rates by rail proved more economical, and the water is now used for manufacturing purposes throughout the Blackstone Valley, and is of great value to the mill owners. Other short canals have not been financially successful in competition with railroads in this state, as shown by their general history.

The Cape Cod Ship Canal, completed in recent years, has been successful in providing a shorter route to New York and the South, and has promise of being a financial success. There is no disparagement intended of water routes in comparison with rail routes if a more economical transportation can be assured, but location, distances, centers of distribution, etc., must be considered in individual cases, and whether a system of inland ways for Massachusetts can be successfully developed remains to be solved by the skill and ingenuity of the engineer.

The conditions in the state of New York, with its network of canals and canalized rivers and large western commerce,

present most favorable conditions for water transportation, which doubtless will show a saving over rail routes. We should all greet with pleasure any developments in waterways and terminals in this state that will prove economical investments for the community.

The attempted regulation and conservation of water power by the National Government has resulted in a chaotic condition of affairs, as indicated by various bills and amendments before the present Congress, which failed to pass. The experience of private water-power development during the last seventy years has indicated the large investments required in building the works and the years that elapse before adequate returns are made to those whose funds are invested. Companies now prosperous have had their times of depression; one company, as was remarked by one of its officers, paid one dividend on expectation and lost twelve on facts. The history of water-power companies in the middle and southern states shows that financial reorganization and readjustment have been of frequent necessity, and investors have suffered accordingly.

Taxing a water-power franchise, which in its development produces taxable property and develops new industries in a community, produces a heavy burden on the subject, and the result has been the abandonment of water-power developments until well-defined policies of the National Government are settled by national legislation.

The general dam law of June 23, 1910, contains such drastic provisions that it has prohibited water-power development in navigable rivers since its enactment. This act authorizes the imposition of rents and royalties to be paid into the Federal treasury upon all water power developed. Since that time bills have been introduced to amend the claims of the Government regarding their rights and charges for this power. It is claimed, apparently with justice, that the United States has no general sovereignty over or property interest in navigable waters, and Congress no power to legislate concerning them except for the regulation of interstate and foreign commerce. If that is the case, Congress has no power to require proprietors of lands upon navigable rivers and owners of riparian rights to pay to the

Federal Government, royalties and charges for the use of their own property. The various states of the Union have sole sovereignty and control over these rivers, holding them in trust for their citizens. Those parties to whom these rights have been granted by the state own all property rights and interest in the beds and waters of the streams, and are entitled to the enjoyment of them to the exclusion of people of all other states, subject only to certain uses for navigation as regulated by Congress, and subject to state rights already granted. These propositions do not involve the power of taxation, federal or state. The property and business of those parties who construct dams are subject to federal and state taxation without special provision. This does not controvert the power of the United States to fix rents measured by the water power developed on public land which is leased for dam sites and transmission lines as provided in the Myers Bill. The Supreme Court, only two days ago, has sustained injunctions ousting certain hydro-electric power companies from Federal forest reservations and upheld Federal and limited state sovereignty in developing resources in public lands in the western states. Regulations of the Departments of Agriculture and of the Interior directing the removal of this property from the public lands unless Federal permits were secured, were sustained. The power companies had permission from Utah to develop water power on the forest reservations for public purposes, and in court they contended that the State and not the Federal Government had authority to permit use of public lands within their borders, even on Federal government land. The Government contended that large resources would be lost to the Federal Government if this view were sustained, and that it would destroy at a blow an important element in the plan of conservation. The state maintained that denial of such authority would be an unjust discrimination in favor of states not containing government land. (Eighty per cent. of Utah's entire area, and large percentages of other western states, consist of federal domain.)

The statement has been made that the maximum water horse-power available in the United States is about 61 780 000, without the development of available storage, only about one

tenth of which is developed and utilized. The power of navigable rivers alone is estimated 27 000 000 horse-power, of which but a small portion is developed. The present arbitrary laws controlling these rivers have limited development since they were enacted to about 140 000 horse-power.

The necessity of abundant power at low cost is imperative at the present time, when efficiency and economy are sought, and some definite policy to enable those developments to be made without delay is urgently needed. It would appear that the present income tax laws cover all that is necessary without further legislation. A dam which will tend to improve navigation, and relieve the Federal Government of a burden, should not be taxed for water power which has been created.

It is gratifying in the national crisis that is so rapidly developing that this Society has offered its services to the National Government through the Committee of Safety of this Commonwealth, and that our Past-President Gow is chairman of the most important sub-committee of defense which includes many other large contractors. Engineers may have many problems to contend with besides those previously mentioned in this address, and certainly no one will fail to coöperate in matters involving the rights of the United States with reference to other powers, and the rights of American citizenship.

The President wishes to express his appreciation of the coöperation of the members and committees during the past year on various matters which have been brought to the attention of the Society, and bespeaks a successful year under the new guidance that has been selected.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

CHINA MILLS DAM AND SLUICEWAY OF SUNCOOK MILLS.

By Arthur T. Safford,* Member Boston Society of Civil Engineers.

With the inevitable decay in wooden dams, the difficulty and cost of buying timber of the dimensions and character required for building them, and the value of any saving in leakage which can be readily transferred into power, the days of the picturesque but leaky dams in New England are fast numbered; and they are rapidly being replaced by tight masonry dams which if thoroughly built make the most permanent and valuable asset to any water power.

The writer had an opportunity this year to replace an old timber crib and masonry dam with a heavy concrete gravity structure which forms the subject of this paper. It is submitted, not with any idea of novelty or because it has solved any unusual problems, but simply to show the tendency towards more permanent structures and the increasing value of water power on our New England streams.

The Suncook Mills at Suncook, N. H., derive their water power from the Suncook River, a tributary of the Merrimack from the east, having its origin in large ponds, in the towns of

Note. This paper will not be presented at a meeting of the Society, but discussion is invited, to be received by W. L. Butcher, editor, 14 Beacon Street, Boston, before August 10, for publication in a subsequent issue of the Journal.

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Pittsfield, Barnstead and Northwood, and entering the Merrimack about seven miles below Concord, N. H. The China Mill, the lowest of the three mills of the Suncook Mills, can be seen from the main line of the Boston & Maine Railroad, just before reaching Concord; the automobile road to the White Mountains on the east side of the Merrimack goes through the village of Suncook; and the state highway from Concord to Lake Winnepesaukee and Alton Bay follows up the Suncook River until it crosses the divide in the town of Barnstead.

On "Plat of Meremack River from ye. See up to Wenepesoce Pond, also the Corses from Dunstable to Penny-cook. Jn°. Gardner." drawn previous to 1670, the Suncook (spelled "Sunckook") is shown as the most important tributary of the Merrimack River from the east.

The drainage area of the river at the China Mill at its mouth is 264 square miles; the hills at the upper part are steep but the valleys broad; the water surface of ponds is about 4 020 acres (or 6.3 square miles); the fall about 424 ft., or 12 ft. to the mile, of which 80 ft. is in Suncook at the Webster, Pembroke and China Mills of the Suncook Mills. At these three mills are approximately 3 000 h.p. of water, of which 1 700 is at the China Mill. The name was given to this mill when its product was mostly heavy sheetings, shipped to the Orient. The mills have a good record, and have been manufacturing cotton cloth at this site since the Civil War.

The China Mill is served by a canal about a quarter of a mile long and of ample proportions, the headgates and coarse racks being located just upstream from the old dam. (Fig. 1.) This dam, built about 1868, was of solid masonry construction for about a quarter of its length on each end, the middle portion being of timber A-frame type with a plank deck on the upstream side. The masonry part was chiefly laid with little or no mortar, the stones being pinned together and partial watertightness obtained by a facing of brick laid in mortar on the upstream side. On the canal side, the dam ended in a masonry pier, between which and the abutment were located two wooden sluice gates, about 4 ft. by 8 ft., intended to drain the pond and to aid in cleaning off the racks. Downstream from this abut-

ment ran a retaining wall about 50 ft. long, built in 1915 of heavy granite blocks laid dry. Beyond this was a gap of about 25 ft. and then a very old loose rubble wall extending downstream for about 60 ft. On the other side was an old abutment wall of granite blocks laid in mortar and extending downstream about 30 ft. below the dam.

The old dam, including the pier and sluice gates, was about 146 ft. 6 ins. long, the pier reducing the effective length by about 8 ft. The average height was about 20 ft., and the head obtained at the mill was about 35 ft. The China Mill has ready for emer-

FIG. 1. THE OLD DAM AND LEAK THROUGH IT. "THE OLD SWIMMING HOLE."

gencies and dry weather an auxiliary steam plant. The pond, extending back to the Pembroke tail water, is small.

Considerable leakage had developed in the old dam, partly in the masonry, but chiefly through the timber portion. This was estimated to amount to perhaps 75 h.p. The timber part was in bad condition (Fig. 2), and, although it had been reinforced with extra bents some years before, it seemed likely that it would fail within two or three years. The possibility was at first considered of patching up the most dangerous places with concrete or other material, but the difficulties in the way of this plan were so great that it was finally decided to build an entirely

new dam downstream from the old one. (Fig. 3.) Later, when conditions made a more thorough inspection of the old dam possible, it was discovered that the wisdom of this decision was unquestionable.

With the water at the crest of the old dam, there was a drop of about 18 ins. over some rapids below the Pembroke tail-

Fig. 2. The Old Dam at Close Range.

race of the next dam above; so it was decided to make the new dam that much higher than the old, thus giving a slightly greater pondage, but particularly a valuable increase of head without damaging the Pembroke power.

During construction, the old dam was used as a cofferdam, and in order to make this possible it was necessary to arrange for wasting the surplus water through the China Mill canal.

At the lower end of this canal, and just below the penstock entrance, was a sluiceway into the Merrimack River, but the lower end of this had been washed out completely. The reconstruction of this sluiceway was therefore made preliminary to work on the dam.

SLUICEWAY.

In the first place, the wooden floor of the remaining part of the old sluiceway was taken up and a new concrete floor laid. The walls were of good masonry and left as they stood. The

FIG. 3. SITE OF THE NEW DAM, 60 FT. BELOW THE OLD DAM.

new portion, 184 ft. long and 10 ft. wide, was then built. The floor and walls were of concrete, 12 ins. thick, and the walls, which were 4 ft. high, were reinforced to withstand earth pressure on the outside. For most of its length it was laid directly on the ground, the soil being of tough clay hardpan, but at the lower end it was built on a low stone fill. (Fig. 4.) At the outfall end in the Merrimack River (Fig. 5), piles and sheeting were driven and the wing walls supported on them to prevent undermining. At the upper end, where there was a straight drop of three feet, railroad rails were laid in the floor to save it from wear. (Fig. 6.) This was also done at the upper end, just below the gate.

Fig. 4. Sluiceway Open during Flood.

Fig. 5. Sluiceway. Outlet into Merrimack River.

Owing to the necessity of using the sluiceway before the concrete had hardened, leaks developed in the floor just below the gate; but the source of these was found after some difficulty and the leaks practically stopped.

FIG. 6. SLUICEWAY. GATE CLOSED.

When the water was first let into the sluiceway, a large hole was made in the new wall. This was probably due to some defective cement. The test results on this carload of cement were somewhat uncertain, but it was decided that they did not warrant holding up the work by condemning it. The whole of the carload was used, but no further trouble developed from it. An adjustment was later made for one half this car. The hole thus

formed was patched later so that it was watertight, but, owing to cold weather coming on, it was impossible to smooth off the inside face of the wall where the patch was made.

The cost of this job was high, owing partly to the nature of the work, partly to inefficient superintendence, and partly to the employment of more labor than was necessary incident to starting both jobs and in order that a sufficient force might be had when the dam was begun. The quantities and unit costs are as follows:

Grading and excavation	179 cu. yds.	@	$2.13 per cu. yd.
Forms	4 115 sq. ft.	@	23.7c. per sq. ft.
Concrete	232 cu. yds.	@	$9.15 per cu. yd.
Concrete, including forms	232 cu. yds.	@	$13.35 per cu. yd.

Total cost of work = $4 185.18

This work was begun about the 8th of August and finished about the 1st of September, when the force was transferred to the site of the new dam.

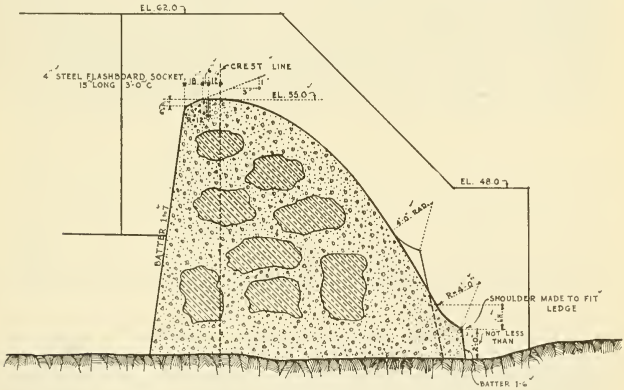
China Mills Dam.

The location of this dam was chosen at a point where the ledge seemed most favorable, 56 ft. 6 ins. downstream from the crest of the old dam. The new dam was made 147 ft. 2 ins. long, which, owing to there being no pier, gave it an additional length of about 8 ft. 6 ins. over that of the old dam. It was designed for a depth of water on the crest of 6 ft., the maximum observed by the mill officials in the past fifteen years being about 4 ft. Certain marks known to have been reached by the flood of March 2, 1896, made the extra 2 ft. advisable. The design was a heavy section of solid concrete, with a batter on the back of 1 in 7, and a parabolic face. (Fig. 7.) The dam was equipped with flashboard sockets.

The abutment walls on each side were carried up 7 ft. above the crest. They were run upstream to the abutment of the old dam. On the north side where the old abutment wall was laid in mortar the new wall was built directly on top of it, the old wall being thought watertight. It later developed that it was not, so that it was necessary to put a thin facing of concrete over it. Downstream on this side, the new wall was sloped down

along the face of the dam, and then turned at right angles and run into the natural soil of the bank. Riprap was laid on the bank as additional protection for about 30 ft. further downstream.

On the south side, where the old wall was of dry masonry, it was faced with about 24 ins. of concrete. Below the dam this wall was sloped down as on the other side, and then run at right angles into the very old dry rubble wall. It was then carried downstream for 25 ft., making a facing for the old wall about



TYPICAL SECTION OF DAM

SCALE 1"=4'-0"

FIG. 7.

24 ins. thick. Beyond the end of the concrete, riprap was laid up along the foot of the old wall for the remainder of its length.

On this side a sluice tunnel 5 ft. square was built which ran through the dam and upstream along the foot of the wall to just below the old sluice gates. At this point a hollow pier was built up to the top of the abutment wall and a gate and hoist installed. The tunnel was made of reinforced concrete. The intention in running it upstream so far was for it to take the place of the old sluice gates when cleaning off the racks, as well as for draining the pond.

Construction was begun at the north end, on the opposite side from the canal, because the concrete plant was located there adjacent to the railroad and highway. The cement used was Lehigh, tests being furnished on each carload. The aggregate was gravel obtained from a bank about a mile away and hauled in carts to the job. The main part of the dam was made of a 1–3–5 mixture, although the sluice tunnel and certain parts of the walls were mixed 1–2–4. The gravel was very clean and did not vary greatly in proportions. A small amount of stone had to be added to the mix, and this was obtained mostly by screening gravel at the bank. Two cars of crushed stone, however, were used for this purpose.

A pool of some depth had been formed below the old dam, and it was found necessary to build a cofferdam across this in order to get at the foundation of the new dam. The foundation was of mica schist, mixed with some softer stone, most of which had been worn away. All loose material was barred or wedged off, but no blasting was done except to break up loose rocks too large to be handled by the derrick. In general, a sound bottom was found with very little excavation; but at several points there were pockets from four to ten feet deep full of loose material. Such pockets were found usually to overlie a stratum of blue clay hardpan a couple of inches thick. It appeared useless to take out the rock everywhere down to this stratum of clay because in all likelihood another would be found some feet lower, and the amount of solid rock above it was enough to insure against any sliding on the clay. In one of these pockets a stream of water forced itself through the clay streak and bubbled up under the site of the dam. This leak was plugged, as far as possible, with bags, and forced back so that it came out near the upstream heel of the dam. Concrete was then poured as fast as possible into the crevice from which the flow came, forcing it back until it came out upstream from the heel.

Another pocket was found at the foot of the old wall on the south side, so deep that to excavate it entirely would have endangered the stability of the wall. It was therefore cleaned out as far as was thought safe, and a seal obtained by carrying the concrete fill for the floor of the sluice tunnel out beyond the pocket to where sound rock lay at a higher elevation.

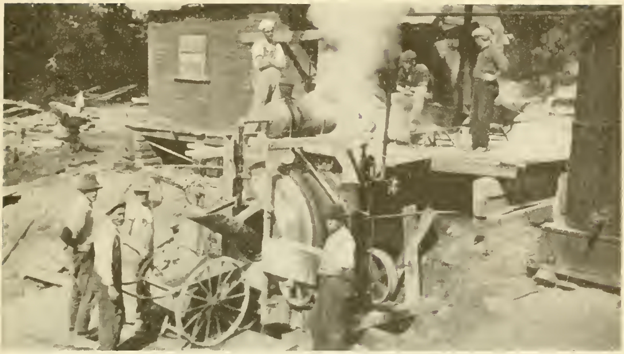


FIG. 8. THE SOURCES OF AMMUNITION AND THE MEN BEHIND.

The dam was built in four sections, beginning at the north end. A trestle was built out from the concrete mixer (Fig. 8), on the upstream side of the dam, and from this the concrete was dumped into the forms (Fig. 9). When convenient, chutes of galvanized iron pipe were used. Large stones, of sizes up to the capacity of the derrick, were placed in the dam as close

FIG. 9. THE CONCRETE GUNS.

together as a proper bedding would permit. These stones were obtained from the excavation and river bed nearby.

When the first section was nearly finished and the second begun, a heavy rain caused a sudden considerable rise in the river. This carried out a portion of the trestle and the forms for the second section, and washed much of the fill out of the coffer-

FIG. 10. A LITTLE HARD LUCK.

dam (Fig. 10). The work was not delayed to any extent, however, because it was possible to go on and finish the first section of the dam during the flood, and when the river went down, the concrete that had been placed in the second section was found uninjured. It was only necessary to rebuild part of the trestle and the forms that were destroyed. It was not necessary to refill the cofferdam, as its chief use was in building the first sec-

tion, and it was found that by plugging a few of the leaks with bags the foundation of the remainder could be kept dry.

Having finished the first and second sections and the north abutment wall, the fourth section, along with the sluice tunnel and the south abutment, was next built. This was a short section, just wide enough to include the sluice tunnel. A leak that had formerly come through the old abutment wall was taken through the new work in a pipe, and after the wall was finished the pipe was plugged. The water then followed along behind the new wall and escaped beyond the end of it downstream from

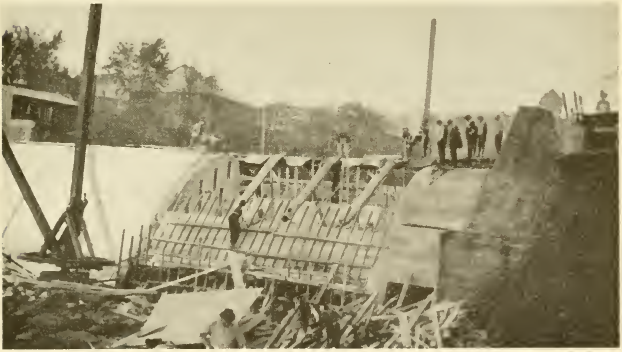


FIG. 11. THE DAM ABOUT FINISHED.

the dam. The source of this leak was not found, and, in view of the necessity for doing some more work in the near future towards improving the entrance to the canal, it was not thought worth while to go to the expense of stopping it.

While this section was under construction, the water that came through or over the dam was taken off through the gap where the third section of the dam was to be; but as soon as the fourth section was finished the water was diverted through the sluice tunnel and the foundation cleaned for the third section. The closing section of the work was thus a plain dam section (Fig. 11), uncomplicated by walls or other details, and

could be poured with the greatest despatch, thus minimizing the danger of another flood. It was practically finished in two days without encountering any difficulties.

The best day's work was on October 11, 1916, when 184 cu. yds., including large stone, were deposited in thirteen hours (8 A.M. to 11 P.M.) at a total cost of $3.98 per cu. yd., including labor and materials.

In pouring the last lift of the first section, some trouble was given by a platform to facilitate dumping the concrete which was built out from the runway trestle and rested on the form. This caused the form to sag somewhat, but too much allowance was made for this, so that the crest on this section is about an inch and a half higher than it should be. This mistake was eliminated on the rest of the work.

After the last section had been poured, the gaps in the walls where the runway trestle had been located were filled in, and the walls were backfilled with material from the excavation. This backfilling was not carried up to the top of the wall, but left somewhat below, so that the remainder of the fill might be made from time to time by the mills.

The walls were designed for a backfilling of loosely laid rubble, thus making them of a fairly light section. The backfilling where the wall was self-supporting was done with this in view.

The old dam was then torn out to below water level, the masonry being thrown over into the space between the dams, and the timber blasted and pulled out by the derrick. The old sluice gates were taken out and the pier torn down to water level, but the gate frame could not be entirely removed owing to water conditions. This was accordingly left to be done when circumstances permitted.

When the pond was filled by the tearing out of the old dam, the new dam appeared to be quite tight, no indication of any leak being found. A considerable leak, however, developed around the north end, escaping over the wing wall below the dam. It was decided to try and stop this by facing the old masonry wall mentioned earlier in this account, and while this stopped most of the flow, enough remained to make a cut-off

wall advisable. Excavation was begun for this, starting at the end of the old wall where it joined the new work and running somewhat diagonally upstream and back into the bank. It was thought that by running the wall in this direction, rock would be found at a higher elevation. The natural soil which had never been excavated was, however, found to be so tight that it was not necessary to go down to ledge except near the wall. When the excavation had got down to the level of the wing wall, water stood in the trench, and, as it was thought that pumping might open the leak wider, the work had to be continued on Sundays, when the pond could be drained out. When ledge was reached and uncovered back to a point where the natural soil began, concrete was poured into the trench up to the level of the top of the dam. From this point up to the top of the abutment wall the wall was made 12 ins. thick. The result was to stop the leak, the very small flow that remained being due probably to ground water. The weather had become quite cold before this wall was finished, but by heating the gravel a good quality of concrete was secured.

Payment on this work was made on the basis of cost plus ten per cent. for the sluiceway and taking out the old dam; on the new dam the same except that the cost was guaranteed not to be more than $18 000 if the quantities did not overrun 2 050 yds. of concrete and 350 yds. of excavation. For any overrun there was to be added to the guarantee $2.00 per yd. for excavation and $8.00 per yd. for concrete.

The quantities and unit costs on the work are as follows:

Dam excavation	646 cu. yds. @ $2.15 per cu. yd.
Dam forms	14 990 sq. ft. @ 17.9c per sq. ft.
Dam concrete	2 385 cu. yds. @ $5.20 per cu. yd.
Dam concrete, including forms,	2 385 cu. yds. @ $6.33 per cu. yd.
Total cost of dam (exclusive of sluice gate and hoist)	$17 436.54
Sluice gate and hoist	$520.55* plus freight on hoist.
Taking out old dam	$182.52
Putting in cut-off wall	$667.17

The total cost of the sluiceway and dam, including preliminary work, engineering and inspection, was $25 300, or $9.67 per

* This does not include commission on gate hoist.

cu. yd. of concrete of all kinds in place, excavation, etc., being figured as preliminary work.

The contractors for the work were the H. P. Cummings Construction Company; the engineer was the writer, and the resident engineer on the job was Walter H. Durfee, of Turners Falls, Mass., Power and Electric Company.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

WHEN TO DIMENSION IN FEET AND INCHES AND WHEN IN INCHES ALONE.

By Sturgis H. Thorndike.*

Many engineers are facing the difficulty of making a rule which will determine when dimensions should be stated in feet and inches and when in inches only. No standard rule has been adopted by engineers generally, and, so far as I can discover, even individual firms and organizations find difficulty in consistently following the rules they adopt. The attempt is sometimes made to set an upper limit, say two feet, using inches alone below this limit and feet and inches at and above it, but no such arbitrary limit can be kept free from exceptions or appears likely to become a final and generally adopted standard. The problem is constantly before any one drawing plans, and consequently is of considerable interest. It perhaps lends itself more readily to consideration in a series of communications to a journal like ours, rather than to discussion at a meeting. It is with the hope of starting such a series that I offer the following suggestions.

For use in engineering structures, the so-called English system of measures provides two units of length, — the inch

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and the foot. My suggestion is that these be regarded as serving two distinctly different functions. The first unit is adapted to stating the width and thickness of any material or member which is constant in cross-section, but may have any convenient length; that is, *the inch is the convenient unit in which to state size as distinct from length or distance*. For instance, we habitually use the terms 30-in. Bethlehem girder beam, 42-in. steel plate, 16-in. brick wall, 30-in. vitrified clay pipe, 38 in. by 50 in. egg-shaped sewer, 36-in. cast-iron water pipe, 12 in. by 16 in. yellow-pine stick, 28-in. stone coping, 16-in. reinforced concrete slab, etc. We seem naturally to use the inch alone in these cases until the dimension exceeds five or ten feet. On the other hand, we do not speak of a 720-in. roadway. I therefore believe that — perhaps subconsciously — we are using the inch as distinct from the foot and its subdivisions as the convenient unit in which to state the *size* of most materials and members.

The convenient unit for *length* or *distance* seems to be almost always the foot. This unit may be divided decimally, but such division is outside the scope of this present discussion. If it is to be divided into inches, and especially if a number of lengths or distances may sooner or later need to be added together, the greatest convenience seems to be attained when the inch is regarded strictly as a subdivision of the foot, not as a different unit, and consequently when we state a length as 1 ft. 7 in., not as 19 in.

This recognition of the existence of two units, one adapted for one purpose and one for another, may clear up much of the confusion and solve most of the difficulties, including the dimensioning of plans. It sometimes results in stating the same dimension in two different ways on the same plan according to the purpose desired; for instance, the size of an I-beam may be 15 in., but the distance from a plate on the bottom of it to a plate on the top of it will be 1 ft. 3 in. Whether this is an advantage or not is open to question; to me it seems an advantage as emphasizing the difference in use between the two units.

There will still remain a wide field for the exercise of discretion. The limit of size to be stated in inches seems to be a matter of judgment and convenience rather than rule. We

speak of a 120-in. wheel base on an automobile, but of a 10-ft. sewer. There will also be differences of opinion on the distinction between size and distance; one engineer will mark his concrete column 28 in. by 32 in. for convenience in figuring stresses; another will mark it 2 ft. 4 in. by 2 ft. 8 in., classing it as a mass of concrete.

I cannot close without calling attention to the fact that this desirability of distinguishing between size and distance, which in our English system induces us to use two different units, hardly exists in the metric system, where, although the units are conveniently distinct, they are so easily convertible that the use of two or more units introduces no confusion or inconvenience.

I trust that this communication may receive attention from other engineers faced with these difficulties, and may draw fire from them to the advantage of all of us.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

NEEDS OF THE ENGINEERS IN WAR.*

THE foregoing chapters have presented a very incomplete outline of some of the engineering duties and a few of the military duties which will devolve upon the engineer company officer in time of war. These subjects are large and have barely been touched upon in this discussion, and there are others which have not even been mentioned. Nothing has been said upon the subject of infantry tactics, which will probably occupy as much of an officer's time as the technical work. Similarly, no mention has been made of the services of security and information, with their subdivisions of outposts, advance and rear guards, patrolling and minor tactics. Camp sanitation, though often introducing problems in disposal of waste and protection of food and water supply which would tax the ingenuity of the average municipal sanitary engineer, has been omitted, and also the subject of military law and government. Coming down to the field of engineering itself, there will be found no mention of roads and railways, though not every engineer knows how to lay a corduroy road correctly, or that the gage of a military railway is made 4 ft. 9 ins., to allow for irregularities of track laying. All these things are beyond the scope of a work of this character, the main purpose of which is to point out the way for the engineer, not to instruct him. It is hoped, therefore, that the material presented will give an idea of the magnitude of the prob-

* From "Military Preparedness and the Engineer," by Ernest F. Robinson. Copyright, 1916, by Clark Book Co. Reprinted by permission of Clark Book Co.

lems which will confront engineers in war, and point out the necessity of individual preparation.

Need of Officers and Non-Commissioned Officers. The army which would be required by the United States as a defense against invasion is placed, by the most conservative estimates, at one million men. In the Civil War we called two million and a half men to the colors, and that was before the days of large armies. With an army of one million we should need 60 000 engineers, of whom 2 000 would be officers and 11 500 non-commissioned officers. The latter are as important to the army as the officers, and particularly so in the engineers. No man should hold a corporal's warrant who is not fully capable of performing the duties of a foreman of construction on civil works, and the grade of sergeant requires a man competent to fill the position of overseer or superintendent on a construction job. Every engineer must not think that his training would in itself entitle him to a commission. Many who entertain this view might find it difficult to hold down a sergeant's job. It is, however, within the reach of every engineer to qualify himself for a commission, and those who do not are contributing to the shortage of officers which will occur upon the outbreak of war, as well as depriving themselves of a military position on a par with their education and social connections.

First-class privates of engineers are skilled workmen: carpenters, blacksmiths, machinists, riggers, electricians, and mechanics of all kinds. Technical men can even find a place in the ranks as sketchers, etc. Second-class privates are of the class of outdoor workmen met at civil works. Lumbermen, miners, boatmen, teamsters, chauffeurs and laborers are fair examples of men useful in the engineers. The lines between the two grades of privates are not closely drawn, length of service, special experience or adaptability often advancing a man from one to the other.

It is probable that many engineers must serve in the ranks as privates and non-commissioned officers, and there is no disgrace in such service. The best citizens of Europe are doing this now, and there is no reason why Americans should be exempt when the time comes. Professor Rawson, in his "Naval

Battles of the World," says of the officers and men aboard the warships, "All in the service are equally servants of the state, and each position is an honorable one, the grades of honor ascending with the degree of responsibility required." A company commander respects and relies upon an efficient and dependable non-commissioned officer as much or more than upon his subaltern officers. Many of the sergeants of the United States Engineers have a reputation throughout the army for their engineering skill, and their practical knowledge of the details of the engineer soldier's work is probably in excess of that of many officers. It means something to be a sergeant in the engineers.

But all cannot be privates, corporals or sergeants. There must be about 2 000 officers, and the engineers of the country must furnish them. There are about 248 in the Corps of Engineers of the Regular Army, and less than 100 in the National Guard, probably less than 300 in all who could be relied upon for active field duty. The field officers can be supplied from the regular army, but about 480 captains, 960 first lieutenants and 360 second lieutenants must be found somewhere, and from where do they come? From civil life direct? Does any engineer reader who has had no military training believe that he can successfully lead engineer troops in the field? Men are quick to detect uncertainty or hesitation in an officer, as a horse recognizes lack of confidence on the part of his rider, and to lose faith in their leader is the first step toward the complete disorganization of troops.

General Morrison, author of "Minor Tactics" and "Infantry Training," says:

"The responsibility resting upon an officer in time of war is great. His mistakes are paid for in blood. To seek a command in war beyond his capabilities is no less criminal than for a man with no knowledge of a locomotive or railroading to attempt running the engine of a crowded express train on a busy line."

National Guardsmen as Officers of Volunteers. Since engineers have taken up seriously the question of military preparedness, the writer has been approached by a number of technical men seeking information regarding service in the engineers of the National Guard. Some of these desire to enter as officers,

which is, of course, not possible except to those who have had definite experience in military engineering. Most of them ask, "How long will it take to become an officer?" To this, no definite answer can be given, as the time required depends upon several factors, — the man's ability, the existing vacancies and the competition developed. In the writer's company, during one year, three technical men, with no previous military experience, were commissioned second lieutenants after one year's service. This required extensive preparation on their part, and more time was spent in study than at regular drills; but any engineer who is ambitious enough to work, and has confidence in his ability to win out in competition with other men, may do the same.

It is realized, however, that, with a large technical personnel in the Engineers, well-qualified men might fail to obtain commissions through lack of vacancies, and thus become somewhat discouraged after a length of service which, in their opinion, should entitle them to advancement. The answer is simple. If you cannot hold commissioned rank in the National Guard, you can insure that in event of war *you will immediately receive the rank for which you are qualified.* Under the provisions of an Act of Congress of January 21, 1903, any person in the army or the National Guard, or with previous experience in either, may apply to the Division of Militia Affairs of the General Staff for an examination in any grade for which he thinks himself qualified. Upon passing, he receives a certificate entitling him to a commission in any volunteer force, outside the organized militia, which may hereafter be raised.

The National Guard can thus perform a great service in fitting men for commissions in the volunteers. A number of militia organizations — as, for instance, the 7th New York Infantry — have always furnished large numbers of officers of volunteers in past wars, and there is no reason why the engineers should not do the same for their own branch of the service. This will require additional work for the officers, in holding schools for the men and instructing them in subjects in advance of their duties in the ranks, and will necessitate extra attendances for the men, but such work would be entirely voluntary, and the

man can decide for himself whether he wishes to spend the time to acquire an officer's training.

The dream of some National Guard officers is an organization at war strength, ready to take the field intact, and, were the organized militia sufficient in numbers for all demands that might be made, such a situation would indeed be ideal. But, under the present system, we must be reconciled to losing our best-trained men to the volunteers, where they will become officers and non-commissioned officers. It would be manifestly unfair, both to these men and to the volunteer organizations, to retain them in the militia for the sole benefit of the latter. Probably the best-trained infantry troops that could be put into the field would be the battalion of cadets at West Point, but their use as such would be very poor management, to let many organizations suffer from a lack of competent officers, in order that one small part of the army might be highly efficient.

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PAPERS AND DISCUSSIONS

THE ENGINEERING SOCIETY IN WAR TIME.

BY GEORGE C. WHIPPLE, PRESIDENT BOSTON SOCIETY OF CIVIL ENGINEERS.

(Presented April 11, 1917.)

AT this first meeting of the Boston Society of Civil Engineers since the declaration of war, the first meeting also at which I have had the honor to preside, I take the liberty of saying a few words as to what our Society should do in war time in order that it may best fulfill its mission, — for I take it that societies as well as individuals must stand ready to do their bit and make such sacrifices as may be necessary for the good of their country. War to-day is, more than ever before, dependent upon the knowledge, skill, imagination and foresight of the engineer. It is dependent also upon organization. It would therefore seem that a society of engineers, composed of educated men skilled in the many branches of engineering science and drawn together by bonds of personal friendship and love of their profession, should be able to do something for the public good which its members cannot do as individuals. What these things are cannot be detailed now. They will develop as the war progresses. That there is work ahead for the Society seems certain. Permit me to make a few general suggestions.

The first is that the meetings of the Society should be kept up. More than ever it will be desirable that we get together and discuss the engineering problems of the war and stimulate our interest in all branches of science. Our regular meetings

should be largely attended, and there should be many special meetings for conference and discussion. Our wits must be sharpened in all possible ways, lest we find ourselves at our wits' end.

My second suggestion is, that, while we meet often, our entertainments and refreshments should be modest and inexpensive, befitting the serious days which lie ahead. It may be necessary to give up some of our customary excursions.

Thirdly, we must rapidly educate ourselves in the elements of military engineering, — because the differences between engineering in times of peace and engineering for war purposes are much greater than most of us realize. We must learn how to adapt ourselves to new conditions, to appreciate the spirit of the military engineer in order that we may aid him if we do not wear the uniform, and in order that we may wear the uniform ourselves if duty calls us. Sanitary engineers are just now surprised and disappointed to learn that because they have no medical degree the army regulations do not permit them to enter the Medical Department, in which the authority over sanitary matters is vested, and that in the engineer corps to which they are eligible there is little or no opportunity to utilize their knowledge and experience. If this anomalous, perhaps calamitous, situation cannot be changed, it will be necessary for sanitary engineers to perform their work as civilians, or to serve the country in other ways. I cannot believe, however, that the situation will remain as at present when once the country realizes that all possible resources are not being utilized by the army to protect the health of soldiers and citizens.

Perhaps the first constructive work which our society can do is to stand solidly behind the new regiment of engineers now being organized in New England. This meeting was called in part to encourage the formation of an engineer corps. Since the call, the First Corps of Cadets has voted to recruit itself to six companies and become a regiment of engineers. We congratulate the organization on its action, and we congratulate the state that it is at last to add an engineering unit to its otherwise well-rounded force, and that the regiment bids fair to be composed of officers and men of exceptional ability. Some of our

members are already officers in this regiment, and doubtless there will be others. This Society, which contains representatives of so many different interests, men who are in close touch with artisans and skilled laborers of all kinds, ought to be of material assistance in recruiting this engineer regiment. It would not be out of place to appoint a special committee to attend to this matter, and to the more general question of engineering service in the United States Army and Navy. Our Society rooms, so well located in the heart of the city, might well be made a center for all matters connected with military engineering.

Also, our Society should keep track of its members who undertake active service, and see to it that no engineer's family suffers from want, and that, so far as possible, the men who go into service do not suffer loss of position by reason of their sacrifice.

Finally, it should be remembered that it is the duty of the engineer to keep things going. He serves his country well who does that duty which is most needed and for which he is best fitted, — whether in uniform or not. Most engineers can probably be of greatest service by helping to keep the wheels of industry and transportation moving, by seeing that the power is kept up; that supplies are ready when needed; that the railroads and highways are always passable; that the bridges are strong enough to bear unusual loads; that water supplies remain ample and safe; that the different kinds of engineering work are properly interlocked. The mutual acquaintanceship of engineers in this Society should do much to make all these activities fit together and run smoothly.

It has been suggested that it would be a good idea for some of our members to contribute to a flag, to be displayed at all our meetings during the war. I heartily approve of the idea, but the Boston Society of Civil Engineers needs no stimulus to its patriotism; she welcomes this opportunity to serve her country, and pledges to the President of the United States the loyalty and support of nearly a thousand engineers.

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MILITARY SANITATION.

By W. P. Chamberlain, Lieutenant-Colonel Medical Corps, U.S.A.

(Presented April 11. 1917.)

The importance of protecting the health of armies is so well recognized to-day that it is only necessary to state that numberless expeditions and campaigns in the past have failed in whole or in part as a result of disease among the troops. One might write an interesting review of history as modified by epidemic disease in armies. I shall to-night only touch briefly on some of the points in military sanitation where the engineer and the physician meet on common ground and where each can be of assistance to the other.

The so-called water-borne diseases have always played an important part in the morbidity and mortality of armies. Typhoid fever, paratyphoid fever, Asiatic cholera, and dysentery are the principal members of this class of maladies. It has come to be recognized of late years that these diseases are conveyed by agencies other than water, — notably flies, dust and contact. Nevertheless the importance of providing safe drinking water is very great, and it is almost equally necessary that sufficient water for proper cleanliness should be provided. In permanent camps, in trenches which are to be occupied for some time, and in fixed military stations, the providing of an adequate water supply is essentially a matter of engineering, and the purification of the supply, if not above suspicion, also demands the services of the sanitary engineer.

In the field and on the march the problem of purifying doubtful supplies requires much attention. In many foreign armies, water carts have been devised, some of which make provision for sterilization by chemicals or by some physical means, such as heat or the ultra-violet rays. We attempted to sterilize water in the field by heat, in the Forbes-Waterhouse sterilizer, but this did not meet all the conditions satisfactorily. The Darnall Filter, which filtered water through outing flannel after using a coagulant, has fallen into disuse because of its bulk. We now depend in the field upon the water sterilizing bag, commonly known as a Lyster bag, taking its name from its originator, Major Lyster, of the Medical Corps. This bag is made of canvas and is 20 ins. in diameter and 28 ins. long. It holds sufficient water to supply a company of infantry at war strength with one canteen full per man. The bag has five spring faucets at the bottom. It weighs about 8 lbs. Calcium hypochlorite is carried in amber glass tubes, in such amount that, when added to the bag full of water, a strength of one part of chlorine in 500 000 is produced. A box weighing 10 oz. contains sufficient hypochlorite tubes to sterilize 5 canteens of water per day for twelve days for one company of infantry. Tubes retain efficiency for ten months.

As a result of oxidation, bacteria are killed promptly, cholera and typhoid bacilli being destroyed in five minutes. Amœba and ciliates, two common protozoal causes of diseases, are killed in fifteen minutes both in the vegetative and the encysted stage. This apparatus is now furnished by the Quartermaster Corps, and one is issued to each company for use in the field.

The number and variety of the means employed to sterilize water in the field are sufficient evidences that the perfect means has not yet been discovered. There is still room for the sanitary engineer to work along this line. Another somewhat allied problem is the devising of a thoroughly satisfactory wheeled kitchen for troops.

Equally important with the supplying of pure water is the proper disposal of the excreta. With a marching command the use of pits, filled in each day on leaving, is satisfactory. In

permanent or semi-permanent camps, something better must be devised, and of course a water-carriage system best meets the needs but is often impracticable. Incineration of the excreta in camps has been tried but has proved unsatisfactory on account of the bulky equipment needed, the expense of operation and the frequent bad odors resulting from the process. The main object to be attained in camp is to keep the flies away from the excreta. This is now managed by the use of a box placed over pits about five feet deep. The box is made as near fly-proof as possible, the seat holes are provided with covers closing automatically, and earth is banked up about the base where the box rests upon the ground. Daily the box is lifted off from the pit, and a fire of oil and straw is made in the pit with a view to destroying paper, sterilizing the walls of the pit and killing any fly eggs which may have been deposited. Recently we have used on the Mexican border the plan of spraying the interior of the pits and boxes with a mixture of coal oil and lampblack or boneblack. This has worked well, the dark interior of the trench and the odor of oil rendering the locality distasteful to the house fly.

There is still room for the sanitary engineer to improve upon the methods of disposing of excreta in the field.

In semi-permanent camps we now dispose of garbage by incineration adjacent to each company kitchen. If the garbage is carried to a central incinerator, some is scattered about the camp, attracting flies; and the garbage receptacles also draw flies. Liquid garbage is evaporated on the rocks, if the incinerator is built of rocks, or in shallow galvanized iron pan if it is built of brick.

There is an excellent opportunity for an engineer to devise a kitchen incinerator which will be simple, cheap, efficient and less wasteful of fuel than our present ones. There is also a similar opportunity for improvement in the handling of horse manure, which, as you doubtless know, is the chief breeding place for the house fly, one of the greatest menaces to health in camp. At present, when the manure from camps cannot be safely disposed of to farmers, it is generally hauled to a dis-

tance and burned on the surface of the ground with the aid of crude oil.

Through the efforts of English army surgeons, it was shown that malaria is transmitted from man to man by the Anopheles mosquitoes. You are doubtless all aware that, through the brilliant experiments of members of our own Medical Department, Majors Reed and Carroll, and Contract Surgeons Lazear and Agrimonte, it was shown that yellow fever was carried by the bite of the Stegomyia mosquito. As a result, Cuba has been freed from yellow fever, and the control of yellow fever and malaria rendered possible the building of the Panama Canal. The control of the mosquito pest is a matter in which great assistance can be rendered by the engineer. Doubtless you are all familiar with the subject as handled at Panama. Among the points to be considered are, the draining of pools and swamps; the application of oil or other larvicides to standing water which cannot be drained away; the construction of concrete drains which leave no pools when flow ceases; the removal of grass and brush from the edges of such drains by burning or otherwise; the removal of aquatic vegetation which protects mosquito larvæ from oil and from predatory fish; the providing of non-sagging gutters for houses; the screening of houses against ingress of mosquitoes, and the proper screening or covering of water receptacles so that mosquitoes may not breed in them.

In time of war, the construction of the hospitals made necessary by the military operations is transferred from the Quartermaster's Corps to the Engineer Corps. Here is a field offering great opportunity for the engineer to devote himself to promoting medico-military preparedness. Problems of ventilation, heating and lighting, and also of protection against insects and against injurious glare, must be worked out. Rapid, cheap construction will usually be demanded, and attention should be given to standardized portable buildings with the material cut the proper size at the mills. Our military attachés in France have recently reported on types of barracks built along these lines by the French and the English, and the Red Cross Society in this country is working upon the same subject at present. The United States Army plans for base hospitals are now under

revision by a board which will investigate all the hospitals constructed last year along the Mexican border.

The foregoing remarks indicate some of the matters in which the engineer may be of direct and vital assistance to the military sanitarian. Work which the engineer may do in promoting sanitary progress will have an important bearing on the ultimate military success of the nation. In the past, enormous losses and untold suffering have resulted from the outbreak of preventable disease among the soldiers. Only in the last few years has it become possible to keep large aggregations of men in good health while in camp. As an example of progress, let me cite the following comparison: In 1898 our forces mobilized for the Spanish War had 22 000 cases of typhoid fever, with 2 100 deaths. Most of these cases were infected in the United States. In 1916 we mobilized about the same number of troops along the Mexican border. We have had 46 cases of typhoid, with 2 deaths. Surely a most gratifying comparison! Other sanitary problems still remain to be worked out, and for their solution let the physician and the engineer march hand in hand, assured that by coöperation lasting success will be achieved.

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PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

ORGANIZATION AND DUTIES OF ENGINEER TROOPS.

By Frederick B. Downing, Captain Corps of Engineers, U.S.A.

(Presented April 11, 1917.)

I shall undertake to describe, briefly, enough of our army organization to make clear the usual assignment of engineer troops therein and tell you something of their duties.

The battlefield of to-day is a very extensive area. In the days of the Civil War, perhaps five square miles was the average size of a battlefield, but to-day it is three or four miles in width and three or four hundreds of miles in length. It is marked by a very elaborate system of trenches that run hither and yon in every direction.

The field is apportioned to certain major units of the army that are called divisions. Each of these divisions will comprise about twenty thousand fighting troops and will occupy a section of the battlefield perhaps three or five miles long. Just behind the battlefield proper are the division headquarters, — one for each division. They are placed sufficiently in rear of the fighting troops to provide reasonable safety to the large quantities of supplies that are concentrated at depots in the vicinity.

Between the division headquarters and the fronts of the divisions operate long trains of motor trucks and wagons which are generally organized into four distinct systems, for the supply of ammunition, quartermasters' stores and sanitary materials.

The fourth system comprises the trains carrying the engineering supplies.

The battle ground, and all of the territory referred to above, is included in what is called the " zone of the advance," and it is this zone which is occupied by the fighting troops. I use the terms " zone of the advance " and "zone of the line of communication " with the purpose of bringing out the distinction that the chief of engineers has made to exist between the " B " service and " A " service of the Engineer Officers' Reserve Corps. The B service is the one in which it is expected that an officer will have but little need of military experience, and is on the line of communications. The A service is the more strictly military duty, is in the zone of the advance, and is called " service of the front."

Back of the zone of the advance is the zone of the line of communications. It takes its name from the fact that it is traversed by a route — usually a railroad — which is the line of communications, and over which the supplies are carried to the front.

Let us start at the rear end of this line of communications which is at the base of the army, and travel forward, making a brief survey as we go. As we leave the base we pass near a very large camp. The men are in barracks or wooden shelters or large tents, in permanent camps, — a large body of troops; estimated at about one hundred thousand. That is the strategic reserve of the army. The whole army comprises at least five hundred thousand men, most of whom are in advance of the base.

Going forward along the line of communications are great numbers of railroad trains. Moving forward, they are full of ammunition, clothing, materials for the repair of trenches, railroad material, and other supplies. Coming back, most of the trains are empty, else they are loaded with worn-out stuff, — materials and men.

As we go along this railroad we see that at practically every important junction, at all of the bridges, and in the larger towns, troops are stationed; and in every instance they are protected by permanent fortifications that have been erected by the

engineers in the service of the line of communication. We also see that the original railroad has been supplemented by additional tracks and that a number of new branch lines, spurs, sidings and yards have been constructed to facilitate the transport and storage of material.

Perhaps eighty miles in front of the base of supplies we arrive at the headquarters of one of the field armies. This field army, we are informed, consists of three divisions; and it constitutes one main section of the long front of the battle line. Within a few miles of army headquarters there is a mobile reserve which is to be used when needed for the reinforcement of any weak or threatened part of this section of the front. In front of army headquarters, and spreading out somewhat like a fan, are the headquarters of each of the three divisions, which we remember are placed near the rear edge of the zone of the advance. We proceed to division headquarters and find that the old roads have all been rebuilt and many new ones constructed. These reach forward over devious ways and end in the covered communications or protected roads among the trenches of the battlefield. We have now traveled up to the fighting position of one field army. We recall that on its right and left are other armies that are organized similarly, and each of which numbers its men in hundreds of thousands.

Now let us see what the engineers are doing. The zone of the line of communication is under the command of an officer termed "the commander of the line of communications," and on the staff of this officer there is one who is called the "director of railways." He is an engineer officer and operates and maintains the railroad from the base to or near the division headquarters. He has charge of the construction, operation and maintenance of all the railroads of the line of communications, and of the establishment of additional trackage and storage facilities for yards, depots and parks required for the advance bases. The personnel which the director of railways controls consists largely of civilians. But, in addition, there are organizations of engineer troops that are regularly assigned to the line of communications, and some of these are railroad troops. Such troops have an organization

similar to the divisional engineers that serve with the combatant troops.

In addition to the railroad engineers there are other troops on the line of communications which usually are pioneer engineers as distinguished from pontonier engineers, — the latter being those that build the bridges. The pioneer troops fortify the base, supervise the construction of the camps, establish and operate the water-supply systems, build and maintain the sewerage systems, and, if necessary, erect lighting plants and operate them; and maintain factories for the supply of fortification materials. They are also engaged when necessary in the construction of wharves, warehouses and hospitals, and in the erection and operation of power plants for various purposes.

On the staff of the commander of each army, — and it is to be understood that the armies are individually commanded by generals, and the grand army by a general-in-chief,— on the staff of the commander of each army there is a chief engineer. Under the direction of the chief engineer of the army, the roads and railroads in advance of army headquarters have been built or reconstructed. Under him are the divisional engineer troops, and other engineer officers in the service of the front that are engaged in conducting what might be called the public works of the army. The chief engineer of the army has charge of all military surveys and reconnaissances; and of the preparation, reproduction and issuing of all maps for the use of the army. He builds and operates power plants and factories, especially for the supply of lumber that is necessary in rebuilding trenches and dugouts.

To each division of the army there is attached one regiment of engineers. These divisional engineer troops are used principally in determining the positions and supervising the construction of trenches, trench communications, shelters and bombproofs; in making surveys and maps; in building roads and bridges; and in placing military obstacles. The latter may consist either in the construction of a dam to flood the country, or the digging of what is called a military pit, the building of a barbed wire obstacle, or the felling of a forest. They are also engaged in digging shafts and galleries; in lining them; in locating and

destroying the enemy's works by exploding mines; and generally, in retreat, in destroying the military resources of the enemy.

Now I have very briefly outlined the duties of engineer troops, but if I have left you with the impression that the work of fortification referred to is entirely done by the engineers, I have given you a wrong impression. You will get some idea of the enormous amount of work that is entailed in the mere collection of the material that is necessary to be built into the defenses of various sorts when you realize that to fortify some parts of a line of battle as it exists in France to-day, a single mile of completely entrenched line may require one thousand miles of barbed wire, one million running feet of lumber and six million sandbags. If the engineers had to do that work alone, it is conservatively estimated that it would take six years to finish the entrenchments. The truth is that the fighting troops — principally the infantry — must do the great part of the entrenching, and thus they leave the engineers free to supervise the especially nasty jobs and to execute the most difficult work.

I should like to impress upon you the fact that the entire region back of the battle front proper is under military control. It is administered for engineering construction and for the operation of public utilities by troops in the military service. It is hardly too much to say that any practical engineer, any one who has experience in construction, or any skilled mechanic, can find his place, and a very useful place, in the military organization of engineer troops. I should like in this connection to emphasize some of the remarks of your president. Fighting with the armed troops in the military service is not the only place where engineers will be useful. They may serve in the factories at home, on the lines of communication in rear, or with the fighting troops at the front. But when we begin to train an army of millions we have got to have fighting men. You cannot have an army without them. I have come rather closely in touch recently — and I am happy that I have done so — with a number of men, old and young, who do not yet know what they ought to do. They are anxious to do the right thing. I do not think it is my part to advise individually what a man should do, but I do feel that if

you are young and strong and want to find your place, you will be most welcome at the front, fighting.

Now, as to what New England should do to furnish engineer troops. Let us make a hasty estimate. Let us figure, first, what a division is. An infantry division consists of three brigades of infantry, a brigade of artillery, a regiment of cavalry, a regiment of engineers, a field battalion of signal troops, an aëro squadron, an ammunition train, a supply train, a sanitary train and an engineer train, — in all, something like 20 000 fighting troops. Now let us assume that an army of sixty divisions is to be furnished by the United States, — that is approximately one million two hundred thousand men. Each division will consist of what I have just outlined. To each division that is at the front there is assigned a regiment of engineers, and to each group of three divisions another regiment of engineers. That is, the ratio of assignment is four thirds of a regiment of engineers to each division. The above are with the fighting troops, in the zone of the advance, — in the A service. In addition, there should be, on the line of communications for each group of three divisions, at least one regiment of engineers as railroad engineers and another regiment as pioneer engineers, which adds, therefore, another quota of two-thirds of an engineer regiment to each division of troops. The quota of engineer troops, therefore, is two regiments of engineers for each infantry division. Now, if the army contains sixty divisions, I reckon that Massachusetts and the neighboring states should furnish at least two of these divisions. Therefore, the engineers from Boston and adjacent country would be four regiments. That is, if New England does its job, — and there is not a shadow of doubt in my mind but it will, — she will furnish for the engineers alone approximately one hundred and fifty officers and four thousand skilled men in the ranks as non-commissioned officers and privates.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

ENGINEERING INSTRUCTION NOW BEING GIVEN BY THE FIRST CORPS CADETS, AND THE FORMATION OF A NEW ENGINEER REGIMENT.

By John F. Osborn, Captain First Corps of Cadets, Massachusetts National Guard.

(Presented April 11, 1917.)

When I accepted the invitation of your committee, about two weeks ago, to talk before you, I hardly realized the march of events which would take place from that time until to-night. To illustrate the uncertainties constantly arising during this time, I might cite to you an occurrence at a meeting of a board of officers at the South Armory, a short time ago. Some question arose as to the latest interpretation of a certain portion of an order which had been published. A prominent regular army officer at that time was trying to explain the intent of the order. He said, as he looked at his watch, "Gentlemen, all I know is that up to 8.15 this order was in force. I do not know what may have happened in the last twenty minutes."

Matters are in the same condition now. Things are moving, and we do not know just what will happen to the National Guard, what will happen in regard to compulsory military service, and in regard to a few other things which are at present engaging our attention. I am not much of a speechmaker, and I shall give you no technical talk. I am merely going to tell you in a conversational way what we have been doing and what we are

trying to do in order to start a new engineer regiment. In the past ten days or so, I have endeavored to explain to various meetings what we are doing. I have answered questions or have tried to answer them, to the best of my ability, and I will try to do so to-night if any one has any doubtful points to clear up.

This matter of an engineer regiment here in Massachusetts has been simmering for some little time. I should say it was about three years ago that Major E. T. Cole, U.S.A., retired, and now stationed at Technology, interviewed the Adjutant-General with regard to forming an engineer battalion in this state. At that time things were different than they are now. We did not know that engineer troops would be needed for some time to come. At any rate, the major did his best to get this battalion started; but at that time it was turned down. He has since given considerable time and a great deal of assistance in trying to push this matter to some conclusion. Personally, on two or three occasions I have tried to get something started; I found out what the major had done, and together we tried to get something under way.

Last June, subsequent to the passage of the National Defence Act on June 3, Circular No. 2 of the Militia Bureau of the War Department was published, calling for a regiment of engineers for the state of Massachusetts, to complete the Fifth Division of the National Guard. This division includes, as you have heard before, the National Guard troops of New England. I received a copy of this circular in the middle of the summer, while I was on recruiting duty, and I determined when I came back to Boston to see what could be done toward pushing this matter further. With the permission of the commanding officer of the First Corps of Cadets, and with the help given me by Major Cole, and through the personal attention given by Captain Downing, to whom you have listened to-night, we were able in a small way to start some instruction in my company of the First Corps of Cadets. I made this instruction compulsory in my own company, and endeavored to get men in the other companies interested, and with good success. I also made it possible for a certain number of business men or engineers outside, who were interested in the work, to come in and work beside our men, in

order to get acquainted and to see if it was possible to get together a nucleus from which an engineer regiment could be raised. Our efforts were fairly successful, and before very long we had a number of men from the other companies watching our operations and finally asking for permission to join the class. We added men from outside, — some of you gentlemen here to-night, — who came and started in on this course.

Now comes the present condition of affairs, and the Militia Bureau has come forward and has asked that this regiment be formed. The Bureau has heard about the work we have been doing in the First Corps of Cadets and has asked our organization to consider the proposition of becoming an engineer regiment. We discussed the matter with our veteran members, with our active members and in the board of officers, and it was fully decided, after Major Mitchell of the Corps of Engineers in Washington came here to explain to us what the Bureau wished, that we would take the steps necessary to become an engineer regiment; and our acceptance of the proposition was wired to the War Department and the Militia Bureau. We then took the pains to push things as fast as possible. We found that it would not be necessary to introduce any new bill to the legislature, but that we merely had to go to the point of having the present militia law modified and changed somewhat. This has been done, or is being done at the present time.

You probably all know what is going on in Washington if you have been reading the papers. You probably have heard a number of reports regarding the First Corps of Cadets being turned down, and as to what we are doing. One paper went so far as to say that we were "mad clear through" on account of the order that we could not be recognized as engineers. I do not think that this was so. I think we were rather at a loss to understand the attitude of the War Department, until we began to read between the lines. As you all know, the matter of compulsory military service is receiving the greatest amount of attention in Washington at the present time. In order to get the compulsory service bill through, it is necessary to prove that other systems are failures. There may be some doubt in the minds of some persons as to the failure of the voluntary system. Per-

sonally, and as to the majority of the members of our organization, we would be very glad to see this bill for compulsory training go through. We feel that it is necessary. We do not like to have it said, however, that our efforts as volunteers or National Guardsmen have been an entire failure.

We would be pleased to have you call at our armory any night, and see what we are doing with regard to the recruiting of this engineer regiment. Personally, I can say that my company, B, up to last night had 183 men pledged for a necessary war strength company of 164, and they are still coming. I would say of these 183 men, however, that we have taken in some and merely enrolled them. We have examined them physically and made out all their papers; we are drilling them and doing everything we can to put them in shape, so that in case we are given the order to go ahead and enlarge to a full regiment we may have the requisite number to go to war strength almost immediately. In my active company, I am allowed, at present, a peace strength of but 100 men. I have at the present time in my active company, or did have up to last night, 68 men. I am, as you see, holding from actual enlistment a large number of men who are not engineers, and who are more or less ordinary men. What we want are men with brains; men who can execute an order when a fair explanation is given; men with strong backs and strong arms. We are getting these men. Last night I took in 9, and as soon as I get through here I am going over to the armory and see how many additional men I have to-night.

I am going to map out this work carefully, and I am going to have 100 men who will back me up and who are able to work with their brains as well as with their hands. We are going to get this regiment of six companies of 164 men per company. We are now a battalion of infantry of four companies, and we have about fifteen officers. We are required to have 36 for the regiment, and our officers are infantry officers in all cases except two. Some of them may resign or ask for a transfer, or they may be assigned elsewhere. Some of them will take up military engineering. You can see from this that we may have positions for 24 officers in the regiment; and there are more non-commissioned officers in engineer troops per company than in infantry.

We must obtain men for these positions who, if not yourselves, may be men in your employ who are of the right sort. We are taking in now such men as electricians, carpenters, blacksmiths and plumbers. The doors of our organization have been opened to men of brains, — good, clean men, strong and willing to work.

The matter of obtaining officers for the regiment will be handled in three ways. One of these consists in retaining the present officers in the corps who wish to stay and work to become engineer officers. The second way contemplates taking those officers who have been recommended to us by the War Department, as having satisfactorily passed the examinations for the position of engineer officers in the Reserve Corps of Engineers. The third way in which a man may become an officer in this engineer regiment is to join our organization as an enlisted man, show what he is worth, make himself valuable, be elected a commissioned officer, pass his examinations and be assigned to duty.

In talking over the matter of this regiment with other men, or when thinking it over yourself, estimate the value of this thing to the young men in your service, even though we may possibly have no war worthy of the name. We cannot, however, sidestep the fact that we are now engaged in and must take a part in the biggest war that the world has ever experienced. We do not know how much farther it will go; and therefore every young man should prepare for military service at once. Such service serves to instill, in the minds of young men, love of country, and the incentive to join in its activities grows. The outdoor life and the benefits that the man gets in improved conditions of health, etc., are inestimable. The discipline and training and the understanding of the value of organization to these young men will be worth a great deal to them when they come back to their peaceful pursuits. The friendships that arise in organizations such as I am asking you to have them join, or to go into yourself, are friendships which will never be forgotten. I have been in this thing for twenty years, but it does not seem to be a long time. After I started in I went with the Eighth Massachusetts Volunteers to Matanzas, Cuba. I had not been there very long before I ran across a man in another regiment, from Kentucky, whom I had known very well in college, and we agreed

that the world was very small indeed. From that time until now I have passed through all grades with the First Corps of Cadets up to the position I hold at the present time. I served for a short time with the Eighteenth Infantry in Texas and made many friends there, and I hope to be with the First Regiment of Engineers of Massachusetts. In all this time I have made many good friends all over the country; and practically wherever I go I meet somebody who has known me or the organization in which I am now serving. This organization has had a hand in every war that the country has ever had. It has never gone out practically as a unit, but it has furnished a large number of officers. We are now arranging to send this organization as a unit; we want it to go out and make a name for itself, and we are taking in the right kind of men to do this. We want the personal help of every engineer in this Society.

Vol. IV SEPTEMBER, 1917 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

HISTORY OF THE BOSTON DRY DOCK.

By James W. Rollins,* Member Boston Society of Civil Engineers.

(Presented February 21, 1917.)

Section 12 of Chapter 748, Massachusetts Legislative Acts of 1911, approved July 28, 1911, in part provides:

"The Directors shall report to the next General Court, on or before the 15th day of January, 1912, all necessary plans and estimates of cost for the construction of a dry dock, equipped with modern facilities and appliances, *sufficient in size for the accommodation of any modern ocean steamship.*"

In accord with this resolution of the Legislature, the Directors on January 15, 1912, only five weeks after their appointment, reported as follows regarding the dry dock:

"The short time which has elapsed since the first meeting of the Directors, December 8, 1911, has been insufficient to enable them to organize a technical staff for the preparation of plans and estimate.

"The approximate cost of a concrete or masonry graving dock adequate for any modern steamship, exclusive of land, would probably not exceed $3 000 000.

"The Directors are of the opinion that a dry dock equipped with modern facilities and appliances, sufficient in size for the accommodation of any modern ocean-going steamship, is desirable and a necessary and essential element in the contemplated development of the port, and recommend that a special appropriation be made authorizing the Directors to build such a dock."

* Of Holbrook, Cabot & Rollins Corporation, 6 Beacon Street, Boston.

On March 4, 1912, the General Court, after having considered the report of the Directors, above quoted, passed an order asking for certain information from the Directors regarding dry docks:

" (*c*) Whether the building of a dry dock is the first essential step in the development of the Port of Boston?

"*Reply.* — The Directors have already stated in their report to the General Court, under date of January 15, 1912, that a dry dock equipped with modern facilities and appliances sufficient in size for the accommodation of any modern ocean-going steamship is desirable and a necessary and essential element in the contemplated development of the port. As a dry dock of this character requires such a considerable time for construction, we regard it as one of the first essential steps in the development of the Port of Boston.

" (*d*) Whether, if the building of a dry dock is the first essential of the development of the Port of Boston, it should not be built from the appropriation of $9 000 000 now at the disposal of said Directors?

"*Reply.* — In view of the fact that the act of the Legislature, Chapter 748 of the Acts of 1911, creating the Port Directors, provided for a special report and recommendation on the subject of a dry dock, and in view of the fact that the Directors have made that report and recommended a special appropriation to build such a dock, the Directors have not considered proceeding with its construction from the $9 000 000 already appropriated, expecting that the Legislature desires the opportunity to act upon its report."

The General Court, taking the Directors at their word, that they had not had time to properly consider the matter, after having suggested to them that the dry dock should be built out of the $9 000 000 appropriated, took no further action, and consequently on December 24, 1912, the Directors voted to allot $3 000 000 for a dry dock, and instructed their engineers to prepare plans and specifications.

The report of the Directors to the General Court in 1912 stated the fact above referred to, and the report of 1913 gave in detail the progress of the engineers' work on the dry dock, presented general plans of it, and gave in full the contract executed with the Cunard, Hamburg-American and International Mercantile Marine Steamship companies, agreeing to build the dock " with all diligence and expedition "; also giving an estimate of the cost of construction of a granite-lined dock as $2 143 000.

In May, 1914, requests were sent out for proposals for the

construction of the dry dock, and bids were received on June 15; the result being that Holbrook, Cabot & Rollins were the low bidders, and on June 22, 1914, the Directors by a majority vote awarded the contract to them.

Then the trouble began. The vote of the Directors developed two minority votes in opposition to the award to Holbrook, Cabot & Rollins, and these minority directors strenuously opposed the confirmation of the contract to Holbrook, Cabot & Rollins, before the Governor and Council.

Various reasons were presented by the opponents, the chief ones being, that there was not money enough to pay for the dry dock, that the plans and specifications were notoriously incomplete; and on the part of the labor unions, that Holbrook, Cabot & Rollins were "unfair" contractors.

The Council at this time was a Democratic body and did not enthuse over a Republican project of port development in the face of the opposition above referred to; and inasmuch as the Legislature had reconstructed the Directors of the Port, making it a board of three men instead of five, the Council, after weeks of delay and discussion, referred the whole question back to the new board for a report and recommendation, on September 2, 1914.

The new Directors thereupon retained Lieutenant Harris, of the Bureau of Yards and Docks of the Navy Department, an expert on dry-dock construction, and referred the whole matter to him. In December, 1914, Lieutenant Harris made a report in great detail and covering the point brought out by the minority objections as to the completeness of the plans and specifications.

To further help the matter along, some one raised the point as to whether the Directors had any authority under Chapter 748 of the Acts of 1911 for the development of the port of Boston, to build a *dry dock*, anyway. This question was referred to the attorney-general on January 19, 1915, and he reported that, in his opinion, "without further authorization by the Legislature, the Directors of the Port are not warranted in entering contracts for the construction of such a dry dock."

Meanwhile the Directors had made contracts for the con-

struction of bulkheads around the site of the dry dock, and also had made contracts with the steamship companies to build a dry dock, as above referred to.

To settle the question, the Governor, on February 18, 1915, sent a special message to the Legislature, asking them to consider the question as to whether a dry dock should be built, and if so, asking them to ratify and confirm the former acts of the Directors in connection therewith.

Here is where we came in for a new experience, — "politics."

The Legislature, or rather some of its members, considered the question only as to whether a $2 000 000 contract should be awarded, and acted accordingly, though, at the hearing given by the committee, no opposition was presented on the question as to the necessity of a dry dock in Boston. After weeks of discussion, the Legislature voted, on May 11, 1915, to build the dry dock and confirm the former acts of the Directors in connection therewith.

The Governor, after signing the act, sent a message to the Directors, instructing them to give a hearing, on the matter of the dry dock, and also on the advisability of confirming the contract with Holbrook, Cabot & Rollins, in face of statements made that the prices of materials had dropped and that thousands of dollars could be saved by re-advertising and getting new bids.

This hearing brought out the same group of witnesses — all the public-spirited men in favor of a dry dock and the existing contract, and the labor unions against the latter.

The hearing being favorable, the facts as to prices not being confirmed, and the report of Lieutenant Harris also being favorable, and the investigations of the Board as to financial conditions being satisfactory, the Board by a majority vote made a report to the Governor and Council, on June 22, 1915, recommending that the contract awarded to Holbrook, Cabot & Rollins be confirmed.

About this time, the Governor went away, to California, on a long trip; and on his return and thereafter, in October, 1915, the question of confirmation of the Holbrook, Cabot & Rollins contract came up before the Governor and Council.

Here again the same scenes were reënacted, the minority member objecting, but finally the political curtain was rung down, on October 13, 1915, when the Governor and Council voted to confirm the contract to Holbrook, Cabot & Rollins, sixteen months after the contract had been awarded to them.

Work was begun immediately on the dredging at the site of the dry dock, and was continued all winter, and in the spring of 1916 work was begun on the cofferdam, between the bulkheads already built by the state, the cofferdam being about 500 ft. long. On the line of this cofferdam the elevation of the flats was about 6 ft. below low water, but a channel was dredged from deep water into the dry-dock excavation, 150 ft. wide and 18 ft. deep at low water, to allow the passage of the dredger and scows.

Our contract provided that we should submit to the engineers of the Directors a plan for the cofferdam, and get their approval of the same, before beginning work.

The plan submitted was practically for the same type as that used on the Charles River Basin lock, which cofferdam was most satisfactory and the conditions under which it stood up for two years or more were much more severe than at the site of the Boston dry dock.

This plan was approved by the acting chief engineer, Mr. Robert E. Barrett; by the naval advisory engineer, Mr. DeWitt C. Webb; by the consulting engineers, Messrs. Charles M. Spofford and Guy C. Emerson; and was also approved by the consulting engineers of the contractors, Messrs. Frederic H. Fay and Charles R. Gow.

Some difficulty developed in the dredging of the hardpan overlying the rock, the dredging contractors finally stating, after an extensive series of tests, that the rock was far higher than shown on the contract plans, and thereupon gave up the dredging inside the cofferdam.

The cofferdam was then closed, and work begun on the earth-fill on both sides of and inside the walls.

The question of suitable fill for the cofferdam then came up, as the material which we had expected to get from the dry-dock excavation — sand, gravel and clay — was not forthcoming; so we had to look elsewhere for our filling.

(As a side note it may be said that while a majority of the Directors were favorable to the contractors, the minority member was strongly opposing any action of the Board which could in any way help them.)

On April 27, 1916, we wrote the Directors requesting permission to get suitable material from any source available for the cofferdam fill. No answer was received to this letter. We did get a permit allowing us to use material being dredged by the state in the Mystic River, which seemed suitable for the lower part of the cofferdam fill, but after dumping 10 000 yds., we found it would not stand up, and so abandoned it. We then wrote the Directors asking permission to dredge material in the Reserve Channel, in a portion of that channel which had not been dredged, and which would be an advantage to the state, saving it the cost of dredging at some future time. This request was denied.

We then brought in heavy clay which we were dredging on our contract outside the dry dock, and for a while this material seemed to be fairly satisfactory. Trouble soon developed, as the material being dumped inside the cofferdam would stand up for a short time, but the action of the tide would flatten it out to a very flat slope. We shut the tide gate and tried to make the fill inside free from tidal action; we succeeded in making a fairly good bank, but it soon slumped and flattened out.

We then again asked the Directors for material in the Reserve Channel, but were again denied the privilege, although we offered to pay 5c. a yard for the material. The vote on this was interesting: one member voted to give it to us for nothing, another for 5c. a yard, and the third member voted against giving us anything. So we didn't get any.

We then bought 1 000 tons of gravel and 5 000 tons of stone, putting all this material in one section about 75 ft. long on the south side of the center line of the dry dock.

About this time we closed our gates again, and as the cofferdam seemed to stand up reasonably well, we began pumping, with a 15-in. and a 12-in. direct-connected pump, they having a combined capacity on the first lifts of about 12 000 gals. per minute.

Soon the cofferdam in the weak section began to twist, being 5 ft. out of line at the top, and the sheeting being inclined in both directions, opening at bottom and closing at top, the rods which held it together either breaking or pulling through the timber.

The stone fill was not satisfactory, as we could not pack it solidly against the sheeting; so we again asked the Directors for permission to dredge material in the Reserve Channel, offering to pay 5c a yard for it, and a majority of the Board voted to allow us this privilege. We then put in about 10 000 yds. of good sand and gravel into the rock fill, and apparently solidified the embankment acceptably.

However, something happened, suddenly, as at high tide, at 8.30 P.M. on July 25, a section of the cofferdam collapsed, and the area inside was flooded.

There has been a great deal of discussion about this cofferdam, its design, and its failure; and the writer believes that in justice to all the engineers concerned, a full statement of conditions and facts is desirable.

The contract borings at the site of the cofferdam showed, in all but one boring, a stratum of silt, stiff clay, hardpan to rock, with no porous stratum whatever. Lieutenant Harris had an additional boring made closely adjacent to the questionable one above referred to, and this was a core boring. The sample produced by the drill showed an absolutely hardpan stratum overlying the rock, and not sand and gravel as shown by the contract borings. Lieutenant Harris in his report to the Directors stated, —

Page 6, Appendix B:

"At my request, your office arranged for an interview between Mr. Rollins, of the Holbrook, Cabot & Rollins Corporation, the low bidders, on the work, and myself. This was principally confined to explaining to me, in general details, the methods this company proposed adopting in carrying on the work if it were awarded to them, and especially the type of cofferdam they had estimated on constructing. From this interview I gathered that this company planned to build an enclosing cofferdam across the entrance to form a complete water cut-off if, on further investigations by borings made by them, this was found necessary.

"I was not definitely informed that steel sheet-piling would be used,

driven to rock, but understood from Mr. Rollins that they planned to use this material if further examinations required. When this contract is awarded, the contractor should be required to construct an enclosing cofferdam, across the entrance, of steel sheet-piling driven to rock, unless further examination of the harbor bottom gives different results from those recently obtained. It would be understood, of course, as now required by the form of contract and specifications, that this would not preclude other necessary protective and precautionary measures along the two sides and the head of the Dry Dock as might be found necessary during the progress of the work."

The writer's judgment on this cofferdam was that it was not necessary to drive sheeting to rock, unless there developed a water-bearing stratum overlying the rock. To make sure of the conditions, we made six additional borings on the line of the cofferdam, and in no boring was any porous stratum found.

Having these facts before us, the final plan of the cofferdam, and location, was settled, the cofferdam being moved out from the end of the dry dock 175 ft. and the sheeting was to be driven at least 5 ft. into the stiff clay.

This was the plan approved by the seven engineers above mentioned, not one of whom questioned the stability of the structure.

In a report to our corporation on this matter of underground water, Mr. Charles R. Gow said:

"Since the proposed sheeting will extend through the silt layer, we can eliminate any question as to that material. The substantial blanket of blue clay which underlies the silt is, of itself, to all intents and purposes, absolutely impervious, and therefore if the sheeting is driven 5 ft. into the layer as proposed, I can see no reason to apprehend any percolation through it. In fact, no better material for shutting out water could be desired.

"The only question remaining for consideration is the possible porosity of the sand, gravel and clay stratum overlying the ledge.

"From an examination of the samples of this material and a discussion which I had with the foreman who made the borings, I am satisfied that the material will prove almost equally satisfactory for the purpose of excluding water as will the clay itself.

"With regard to the question of a possible water-bearing seam between this material and the ledge, I have serious doubts if such a general condition could exist, as it has been my observation in the past, that this material is almost invariably cemented to the ledge itself, and while an occasional pocket of coarse material might be found here and there, at scattered intervals, such a condition will be in general unusual.

"I see no reason to believe that the use of the proposed design will lead to any troublesome leakage. On the other hand, I believe it is absolutely improbable that any form of sheeting can be successfully driven through this hard material to the ledge."

Mr. Gow's judgment of subsoil conditions has been absolutely justified by the development of excavation now made (May, 1917).

No leaks of any importance came through the cofferdam, only one, of a few gallons per minute, at high tide; and on the east side two close together from a gravel stratum on top of the rock were developed. The hardpan overlying the rock, at some places 8 ft. in depth, is so hard that a most powerful Marion shovel has difficulty in digging it; and Mr. Gow's statement regarding the impossibility of driving any kind of sheeting through this material has also been proven true, as we tried to drive steel sheeting, for a test well, to rock, with a heavy steam hammer, and were unable to get it through the hardpan.

With the results of all these investigations in mind, backed up by the opinion of all the experts, and the proven stability of a similar dam under more serious conditions, we felt absolutely justified in proceeding with the construction of the cofferdam on the approved plan.

We have omitted one interesting episode in the history of the cofferdam. In February, 1916, certain interests protested to the Governor that the cofferdam we were constructing would endanger the lives of the workmen, who would have to work "hundreds of feet below the water level"; so the matter was referred to the Directors. The correspondence in the case follows:

(COPY.)

BOSTON, February 24, 1916.

Civil Engineer F. R. HARRIS, U.S.N.,
CHIEF OF BUREAU OF YARDS AND DOCKS,
NAVY DEPARTMENT, WASHINGTON, D. C.

My dear Mr. Harris:

In your report dated December 1, 1914, to the Directors of the Port of Boston in the matter of the Commonwealth Dry Dock at South Boston, Mass., you made several references as to the advisability of using steel sheet piling driven to rock in the construction of the cofferdam across the easterly

end of the Dry Dock unless further examination of the harbor bottom should give different results from those previously obtained.

After the approval, on October 13, 1915, of the award of the dry dock contract to Holbrook, Cabot & Rollins Corporation, that firm caused a series of six borings to be taken along the proposed site of the cofferdam. Blueprint copies of sketches showing the results of these borings are appended, marked "A" and "B." These borings were made by Mr. Charles R. Gow (Mem. Am. Soc. and President of the Boston Society of Civil Engineers), and a copy of Mr. Gow's report, dated December 31, 1915, on these borings and on foundation conditions at the site of the cofferdam is appended, marked "C."

During the latter part of December, 1915, the question of cofferdam design was discussed informally with the contractor. On December 23, 1915, the contractor submitted a tentative design with a letter of the same date, a copy of which is enclosed, marked "D."

On December 30, 1915, a further communication on the subject was received from the contractor, a copy of which is attached, marked "E," and on the same date a revised plan of the cofferdam was submitted bearing the approval of Mr. Frederick H. Fay (Mem. Am. Soc.) as consulting engineer.

Copies of the contractor's letter and of the cofferdam plan are attached, marked "F" and "G."

The Directors had been kept informed by their Acting Chief Engineer of the above steps and particularly of the fact that while your report advocated the use of steel sheet piling driven to bed rock, the contractor did not propose to use this material for the reasons set forth in the attached letters.

On January 4, 1916, the Acting Chief Engineer, by the authority of the Directors, submitted the question of the cofferdam design proposed by the contractor to Professor Charles M. Spofford (Mem. Am. Soc. and head of the department of civil engineering at the Mass. Institute of Technology) and to Mr. Guy C. Emerson (Mem. Am. Soc. and consulting engineer to the Finance Commission of the City of Boston) who were some time ago retained by the Port Directors as an advisory board in connection with engineering questions. In submitting this matter to these gentlemen, particular attention was invited to that part of your report in regard to the use of steel sheet piling.

On January 10, 1916, Professor Spofford and Mr. Emerson having examined the plans, specifications and other data submitted to them, recommended the approval of the design. On January 11, 1916, the Acting Chief Engineer, Mr. Barrett, transmitted the report of Professor Spofford and Mr. Emerson to the Directors and recommended that the design submitted be approved "subject to contract requirements." This report was concurred in by Civil Engineer DeWitt C. Webb, U.S.N.

On January 13, 1916, the Directors voted to approve the recommendation of the Acting Chief Engineer, and on January 15, 1916, it was accordingly approved. Construction of the cofferdam was begun on January 27, 1916, and it is now about 10% completed.

Under date of February 9, 1916, the Central Labor Union sent a letter

to His Excellency, the Governor, a copy of which is attached, marked " H." On February 23, 1916, His Excellency, the Governor, and the Executive Council gave a hearing to the representatives of the Central Labor Union in regard to the contents of the above letter. A copy of the brief read by the Chairman of the Port Directors at this meeting is appended, marked " I." After a brief discussion during which statements were made that the construction of the cofferdam without steel sheet piling constituted a source of danger to the dry dock workmen, the subject was referred to the Port Directors for a report.

As the point which is now raised — the safety of workmen — was not specifically covered in your former report, the Directors would appreciate your consideration of and report on the following questions at as early a date as may be convenient.

1. In your opinion does the construction of the cofferdam as approved, subject to contract requirements, constitute a menace or source of danger to the lives of workmen engaged in the construction of the dry dock.

2. Any other points in this connection which you may desire to cover.

Very truly yours,

(Signed) Edward F. McSweeney,
Chairman.

(Copy.)

Washington, D. C., February 28, 1916.

Directors of the Port of Boston,
40 Central Street, Boston, Mass.

Gentlemen:

I am in receipt of your Chairman's communication of February 24, 1916, in which in the concluding paragraph you ask:

" In your opinion will the construction of the cofferdam as approved, subject to contract requirements, constitute a menace or source of danger to the lives of workmen engaged in the construction of the Dry Dock? "

While, of course, desirous of answering your question or giving the opinion requested in a direct and brief manner as possible, I find I am unable to do so within the restrictions I understand to be imposed by the question as written, and for other reasons which complicate the issue and which I will give hereinafter.

It is apparent that any probable menace or source of danger to the lives of workmen engaged in the construction of the dry dock that may be occasioned by the cofferdam contemplated, will naturally be dependent upon the security or safety of that cofferdam and I do not understand that your question involves the matter of menace or danger to life or limb of workmen incident to the construction of the cofferdam itself or to the ordinary accidents and casualties which unfortunately are too often inevitable in the carrying

through of work of magnitude such as would be the case in the building of this dry dock. Restricting the menace of danger in the manner I have indicated to cofferdam failure, I would state, as you yourselves undoubtedly know well, cofferdams of the character contemplated to be built by you, do not, as a rule, fail suddenly. There is usually ample warning of impending failure so that your representatives, and undoubtedly the contractors themselves, would, under ordinary circumstances, have an opportunity to safeguard the lives of workmen. I only know of one such sudden failure and this did not result in death or even injury. However, it is not impossible that a cofferdam might fail suddenly and through unforeseen circumstances, cause injury and loss of life. I do not think it necessary or desirable that I should follow out an investigation involving theorizing on probabilities to this extent. You are as well qualified as I am and perhaps better so, to arrive at a conclusion on this scope of the question, so that my answer to your question within the restrictions I consider imposed, is briefly stated as follows:

In my opinion a cofferdam of the character contemplated, if it failed would probably not fail so suddenly as to menace or endanger life but it might so fail if it failed at all.

I have not examined or inquired into the probable safety of the cofferdam proposed by the contractors, Holbrook, Cabot & Rollins Corporation for the following reasons:

(*a*) The opinion asked for in your communication apparently does not contemplate that I shall do so.

(*b*) The data furnished to me by you as appendices to this communication is not of such a character as would permit me to express an opinion on the sufficiency of the contemplated cofferdam. Blueprints A and B purport to show the results of borings made by the Holbrook, Cabot & Rollins Corporation. It is not stated that such borings were made under the supervision and subject to the examination of your representatives. There is nothing to show that water pressure tests have been made in each case at various elevations such as were made under my directions in the case of the exploration borings upon which my original opinion was predicated While you have forwarded to me a copy of a letter written to the Holbrook, Cabot & Rollins Corporation, signed by Mr. Charles R. Gow, Mr. Gow draws certain conclusions which perhaps with his knowledge of local sub-soil conditions in the vicinity of this work, are well warranted and for which deductions he takes the responsibility. But when you ask for my opinions I, of course, would find it inadvisable to express them except where they are based upon certain examinations made by me or by others in accordance with methods which I should have the privilege of choosing and with an opportunity to make such personal examinations as I thought necessary.

(*c*) The proposed cofferdam design has been submitted by you to a board of consulting engineers, retained by you, consisting of Messrs. Spofford and Emerson, who, after examination of same, have recommended approval of the design, and furthermore have been examined by your Acting Chief Engineer Barrett and by Civil Engineer DeWitt C. Webb, U.S.N., who have

concurred in the approval of Messrs. Spofford and Emerson. Presumably, Messrs. Spofford and Emerson are still acting in the capacity of consulting engineers for your Board, and it would be manifestly improper and unprofessional for me to in turn pass on a question that they had already acted on without first being requested by them to do so, unless their connection with your Board had already ceased before the date of communication to me of February 24, 1916, which, I understand, is not the case. The same professional restriction applies with respect to Messrs. Barrett and Webb. Or to state the matter more concisely, all of these four gentlemen have had before them my report to you of December 15, 1915, with the precautionary views expressed by me as to the cofferdam construction, and they have in full knowledge of this, with opportunities for personal examination on the site of boring data, direct conference, etc., recommended approval of the cofferdam plan proposed by the contractors, Holbrook, Cabot & Rollins Corporation and by their consulting engineers, Messrs. Gow and Fay, and I am unwilling and decline to enter into what might be a controversy affecting the action these gentlemen have taken in good faith and in the discharge of their professional duties in passing on the plans submitted to them, unless either these gentlemen join in requesting me to do so or are no longer connected with your Board officially as employees or retained as engineers at the time that you formally ask for my opinion in the matter.

Respectfully,

(Signed) F. R. Harris.

As before stated, the cofferdam collapsed on July 25, 1916.

Careful studies of the wreck were made and conferences held with the Directors' engineer, our experts and the men in charge at the time of the failure. Inasmuch as the cofferdam had stood up under greater tides with less filling, it never was satisfactorily explained why the failure came, but the probable cause was the sliding of a great mass of the clay either in the fill or in the natural ground, which released the stone and gravel fill on the inside of the wooden structure, and so allowed that to break.

The writer's first plan was to dredge out the whole clay stratum and drive steel sheeting through the hard pan to the rock, if possible. Further study and thought resulted in the belief that the great mass of rock, gravel and clay which was left in the break at about low-water level, was so secure and solid that it would offer the best kind of a "toe" to hold the new fill; the plan being to build a new piece of cofferdam around the

break, using the same design of a wooden dam, excepting an additional spur pile and heavy X-bracing.

Just at this time the Directors of the Port were abolished and the Commission on Waterways and Public Lands appointed, and it was " suggested " to us by a state official, that we " wait a bit " before going ahead with the repairs to the cofferdam.

The Commission thought it proper and wise to get other experts to report on the cofferdam, and retained Messrs. Ripley and Barnes, of Albany, N. Y., as consulting engineers. These gentlemen came to Boston, visited the Dry Dock, asked a few questions of the engineers of the Commission and of the contractor, one of them at least took his first sail in Boston Harbor, on a power boat, out to the dredge and back, and soon after made a report, a copy of which follows:

Boston, Mass., August 23, 1916.

Commission on Waterways and Public Lands,
State House, Boston, Massachusetts.

Gentlemen: In accordance with your oral instructions we have made a careful inspection of the local conditions at the site of the Boston dry dock, the construction for which is now under contract with the Holbrook, Cabot & Rollins Corporation. Examination was also made of the cores of the borings taken on site of the dry dock. The records of the borings were studied and the reports submitted by the different engineers connected with this work and the correspondence relating to borings and cofferdams have been read. We are now prepared to submit a preliminary report on the reconstruction of the cofferdam, which failed on July 25, 1916.

It was noted that the cofferdam, as built, consisted of two rows of timber sheeting 6″ thick, the inner or westerly row being 35 feet long, and the outer row 40 feet long. The sheet piling was driven about five feet into the blue clay. The two rows were eight feet apart and the space between was filled with the blue clay which was excavated from the bed of the bay over the site of the dry dock. Along the westerly face of the timber sheeting an embankment was built of the blue clay material, topped with gravel and large pieces of granite riprap. This bank was about 15 feet wide at elevation 110.0, and its maximum height was at elevation 114.0. Before the construction of the cofferdam the contractor had excavated a channel to a depth of 18 feet at low tide for the passage of his floating plant.

The borings show that the bed of the bay is silt and peat. Underlying the silt is a layer of blue clay five to twenty-five feet thick; then, underneath the blue clay and immediately overlying the rock is a blanket five to twenty feet thick of sand, gravel and stiff clay. The break occurred where the con-

tractor had excavated the channel above mentioned, and some 250 linear feet of the dam was involved in the movement. For about 100 feet both rows of the timber sheeting were broken. The clay and riprap filling placed westerly of the sheeting was washed into the dock pit, being flattened to a slope of about 1 on 5.

At the time of our inspection excavation of this material was being made with an orange peel bucket. It was noted that the rehandling of this material had reduced it to a soft, mushy consistency. At our request the contractor pulled several pieces of the timber sheeting from both the inner and outer rows near the center of the break. Examination was then made of the location and character of the breaks. The contractor also drove a round timber pile 50 feet long about 40 feet into the material near the south end of the break. At this depth the pile failed. The pile was then pulled and the break was found to be about 10 feet from the lower end.

Records show that the tideway gates were closed at noon on Monday, July 10, 1916, and pumping was started on July 12. A movement of the sheeting started with the first high tide after the tide gates were closed and varied from a few inches to nearly two feet in mid-section of the cofferdam. The recovery towards original position at low tide was nearly equal to the high tide movement. This continued for five days, after which no recovery is indicated, but the top of the sheeting tended to progressively move to the west.

It is evident that the embankment placed west of the dam had started to slide and no longer fulfilled its purpose of supporting the sheeting. With the lowering of the water from the dock pit about eight and one-half feet, a head of about 18 feet at high tide was created. This was more than the cofferdam nine feet in width could withstand, and its failure naturally followed.

Mr. Rollins, one of the members of the firm of contractors, informed us that they planned to repair the cofferdam by practically the same construction as originally used, except they would drive a better pile for each of the vertical round piles along the westerly row, and would use sand and gravel for filling the cofferdam and for the embankment alongside.

From our experience with clays similar to the blue clay underlying the silt on the site of this cofferdam, we believe that another break will take place while the dock pit is being unwatered or shortly after the unwatering has been completed, if the cofferdam is repaired as planned by the contractors. We are also of the opinion that the shore ends of the dam now in place are likely to fail, and it would be surprising if they do not, if subjected to extreme conditions which will obtain during the construction of the dock.

The material remaining along the westerly face of the present cofferdam will surely slide into the dock pit when the support of the water is withdrawn. Slides of this material are liable to start at any time, but more particularly when blasting of the rock is being done. It is, therefore, our judgment that the present cofferdam cannot be made adequate, and should be abandoned. An entirely new cofferdam of different design should be built on a location about 150 feet from the present one.

The essential requirements of the new dam should be:

(*a*) Stability within itself.

(*b*) Pounded in firm, unyielding material.

(*c*) Shall cut off, so far as practicable, flow of water in any of the formations overlying the bed of rock.

There are various methods by which these essential features can be accomplished. Among them might be mentioned the pneumatic caisson method; a stone filled timber crib placed in a trench excavated into the gravel formation; steel sheet piling with gravel fill.

We have considered these and other types of cofferdam construction, and, for various reasons, have discarded all but the steel construction.

We, therefore, recommend the steel piling construction, largely of the cellular type, gravel filled, each piece of piling to be driven to refusal with a steam hammer, properly adapted to this class of work.

Owing to the urgency of this preliminary report, details of design have not been fully prepared, but completion of design can be made if desired, so as not to delay progress of the work.

When the location for the cofferdam is determined upon, the elevation of the rock surface and character and depth should be developed by borings.

We have made only a rough estimate of the cost of a steel piling cofferdam, gravel filled, on the last location. We are of the belief that this can be constructed of new steel for less than two hundred thousand (200 000) dollars. We have ascertained that the material can be delivered in Boston as rapidly as it can be used. The time of construction should not extend over a period exceeding ninety days.

We have also ascertained that second hand sheet piling is available for a considerable part of the piling construction. If obtained it will materially lessen the cost of construction.

Respectfully submitted,

(Signed) Joseph Ripley
M. G. Barnes
Consulting Engineers.

(Copy.)

September 26, 1916.

Commission on Waterways and Public Lands,
Boston, Mass.

Gentlemen:

Our report dated August 23, 1916, relative to failure and reconstruction of the cofferdam located at east end of the dry dock pit was followed by oral request for making sixteen wash drill borings at indicated places. Your Commission had the borings made and also, in connection therewith, the necessary tests to determine the flow of water into and out of the pipes used for casings.

The kind of material and its permeability will be more fully determined

when the test pit has been excavated to rock. However, the borings and water tests show that the water in several of the pipes fluctuates with the tide with an amplitude of about eight feet and lags behind the tide about one and a half hours. The inflow as determined by pumping ranged from a small amount to as much as twenty-one gallons per minute. This shows the advisability of having the cut-off curtain of the cofferdam extended down to the rock surface.

The borings also disclose the greater depth to and the variable change in dip of rock surface along the location suggested by us for site of a new cofferdam about 150 feet east of the present one. The range in depth of rock is 45 to 66 feet below low tide. The latter depth will make it both expensive and difficult to drive sheet piling to the rock. A change of location is therefore desirable, and rock surface some fifteen feet higher, or about elevation 50.0 can be found just east of and close to the present dam, or within 100 feet west of it. On either of these locations the estimated cost of the cellular type of dam, extended at both ends into the side embankments with a single line of sheet steel piling, will be approximately $130 000.00, allowing for salvage saving on the steel sheeting. The west location involves moving the dry dock westerly 200 to 400 feet. The elevation of the rock surface permits this to be done if desired.

While examining the test pit yesterday we noted that the contractor was progressing the repairs to the broken part of the cofferdam by placing the six inch timber sheeting.

Under the conditions existing we respectfully advise your Commission to notify the contractor that on account of the failure of the cofferdam as built, the present Commission does not approve of that type of construction, believing that the design is not suited to the material encountered. Also that the Commission is ready to pass on any plans the contractor may submit for a cofferdam but that its approval will be given only to such a plan as the Commission believes to be safe and efficient. Silent acquiescence in the contractor's methods of repairing the cofferdam is at least a negative approval of his type of construction, and in case of failure the Commission may have to share responsibility therefor with the contractor.

A further study just made of the material as disclosed by the recent borings confirms our previous recommendation as to the cellular type of cofferdam being the proper one to build for this place.

In connection with the contract item "Cofferdams," your attention is invited to the bids submitted for this part of the work, the amounts ranging from $40 000 to $280 000. As the pumping alone during the three years' construction period will cost more than $40 000, it is plainly evident that the contractor's bid price for this item is much too low and shows an unbalanced bid.

Respectfully submitted,

(Signed) JOSEPH RIPLEY
M. G. BARNES
Consulting Engineers.

(COPY.)

JOSEPH RIPLEY
CIVIL AND CONSULTING ENGINEER
350 WESTERN AVE.,
ALBANY, N. Y.

DECEMBER 13, 1916.

COMMISSION ON WATERWAYS AND PUBLIC LANDS,
BOSTON, MASS.

Gentlemen:

The examination made by us yesterday of the cofferdam reconstructed by the contractors across the east end of the site of the dry dock disclosed that some of the large pieces of granite riprap at the time of the break had been so deeply imbedded as to rest on the gravel formation and form a toe to the reinforcing embankment. There is some leakage through the superstructure of the dam between half and full tide, the water flowing clear along down the inner slope of the reinforcing embankment at the rate of 100 gallons per minute. The material in the northeast corner is soft and is not supported, the toe being at edge of water in lower pool. Mr. Rollins, the manager member of the firm of contractors, stated to us that he proposed to build a bulkhead enclosing the northeast wing wall. That construction will help prevent the bank from sliding, when the excavation is made 25 feet deeper, for the wing wall. The ridge of rock extending across the dock site and dividing the inclosed area into two parts is very favorable for the contractor as he will have to deal with one part at a time. It is our judgment that the cofferdam from the spillway to the north end should be strengthened by depositing more sand and gravel on the tidal side, and especially it should be well banked up for 100 feet from the north end. The order of prosecuting the work by the contractor will have an important bearing on the safety feature of the work. The best assurance from failure of the cofferdam will obtain if the wing walls and apron are built first and then the side walls westerly to the high ridge of rock. By watching the slopes constantly and taking needed precautionary measures, there should not be any serious slides along the sides of the dock pit. Owing to the unstable conditions at the northeast wing, it is advisable to bulkhead that portion of the work and if possible complete the wall before the spring breakups and heavy rains.

Respectfully,

(Signed) JOSEPH RIPLEY
M. G. BARNES
Consulting Engineers.

(COPY.)

JOSEPH RIPLEY
CIVIL AND CONSULTING ENGINEER
350 WESTERN AVE.,
ALBANY, N. Y.

DEC. 14, 1916.

COMMISSION ON WATERWAYS AND PUBLIC LANDS,
BOSTON, MASS.

Gentlemen:

The cylinder of steel sheet piling having been driven to rock at elevation 56 and the excavation of the test pit completed, we made an examination thereof and also of the physical conditions now existing at the South Boston dry dock on Monday, December 11, 1916. The pumps were started November 1 for unwatering the dock pit. The rate of lowering the water surface was purposely slow so as to give the inclosing banks time to gradually drain out and harden. A ridge of rock and hard compacted material was found extending across the pit a little to the east of center station with its top ranging from elevation 82 to 90. We found that the water surface in the west pool was at elevation 84 and in the east pool at elevation 74. The inflow of water into the dock pit as computed from the gauged flow amounted to about 500 gallons per minute and has not varied greatly from that amount during the six weeks' period of pumping. The water standing in the bore holes previously made has lowered in amounts depending on their distance from the dock pit. The evidence gained from these holes together with the pumping record leads us to the conclusion that the material is not excessively water-bearing. It does show, however, that it is sufficiently water-bearing below elevation 80 to permit the banks to drain out and readily become stable. The water has been drained from the grounds inclosing three sides of the dock pit as is shown by the lowering of the standing water in the bore-hole pipes some seven feet. The water in the pipes still follows the tidal changes, but with a much lessened amplitude, which we interpret to indicate a small quantity of water in the ground, which is generally subjected to quite high pressure. The material excavated from the test pit furnishes definite information as to the kinds and depths of materials encountered. This information is much more conclusive than could have been obtained from the small bore-holes made. The excavation of the test pit furnished very definite information as to variance in materials encountered. After the overlying filling, the silt and soft clay had been removed down to elevation 80, an intrusion of fine sand and gravel was found. Coarse gravel appeared at elevation 75 and largely predominated to elevation 65, then a blanket of hard clay, sand and gravel about nine feet thick overlying the slate rock. We had a half-inch hole drilled through the steel sheeting on south side of pit at elevation 75, and inch holes drilled at elevations 70 and 65. No water came through the upper two holes and only a cupful through the lowest hole. Undoubtedly a cone-shaped portion of surrounding ground with its apex at bottom of the pit had been drained of water by the pumping out of the test pit. If half a dozen

similar test pits had been made in suitable locations quite definite conclusions could be made as to the probable stability of the banks and amount of pumping necessary to keep the pit dry. However, after examining the exposed slopes it may be reasonable to assume that the main part of the banks will average about the same as was found in the test pit, and that the material below elevation 80 will be firm and stable at a slope of 1 on 2 or thereabouts. It is our opinion that the expenditures made for the test pit were fully warranted, for the value of the information obtained therefrom exceeds the cost.

(Signed) JOSEPH RIPLEY
M. G. BARNES
Consulting Engineers.

This report, as will be seen, condemned the whole scheme of our cofferdam; these experts asserting their belief that the balance of it would collapse and recommending the construction of a new cofferdam, of steel sheet piling, of cellular construction; estimating the cost of this as $200 000.

Regarding self-supported cofferdams, the writer has "no use for them," and it is of interest to read the opinions of other experts on this type of construction, having reference to two of the heaviest cofferdams ever constructed, viz., the cofferdam for the battleship *Maine* and the one for the 46th Street Pier in New York. These opinions are:

THE MAINE COFFERDAM AND ITS LESSONS.
(*Engineering News*, July 23, 1914.)

"The *Maine* cofferdam was composed of a series of circular cells, each 50 ft. in diameter. Total length about 1 000 ft. Cells were filled with mud. Depth of water 35 ft. with mud bottom about 120 ft. above rock. Piles were 70 ft. long and penetrated about 10 ft. a dense mud or clay stratum. The cylinders proved anything but rigid; they bulged and broke. Large amounts of riprap were dumped inside the dam, and finally heavy braces across the excavation had to be installed. The original estimated cost of the work was $300 000 and the total expenditure $785 774.83."

COFFERDAM FOR 46TH ST. PIER, NORTH RIVER, N. Y.
(*Engineering Record*, July 18, 1914.)

"Extended analyses and computations showed that pockets large enough to possess independent stability due to the width of base and the gravity moment would require very large dimensions and the material available for filling was not suitable or satisfactory. . . . It was believed that a single line

of steel sheeting to serve as a water-tight core for a dam embankment would not have sufficient stability in the soft river bottom before it was reinforced by the embankment, and it was therefore determined to provide pockets large enough to give independent stability during construction, but not large enough to resist the final working pressure, and to reinforce them by the deposition of heavy fills of riprap in the interior of the dam which are calculated to be strong enough to resist the thrust while the pockets filled with soft material exclude the water."

We, as contractors having faith in Boston engineers and our own judgment of conditions at the cofferdam, and having no particular faith in the opinion of engineers who had no knowledge of general Boston Harbor conditions, or of our cofferdam in particular, declined to consider their recommendations, and after waiting several months for some word from the Commission, began work on the repairs, and pushed this work through to completion on November 1, 1916, and on November 2, 1916, we began pumping.

We had no difficulty in pumping the water down to Elevation 80, and in fact we had to shut down the pumps at frequent intervals to allow the water to drain out of the slopes.

From Elevation 80 down to Elevation 70 we were troubled with the soft mud and clay, which kept sliding into our pump well, and which clay and mud we had to remove with a large clamshell bucket, with a cableway; a slow process.

At this date (May, 1917), the excavation at the outside end is down to Elevation 57, and the lower half down approximately to rock. The leakage is remarkably small, a six-inch automatic pump easily controlling the water; not working half the time.

The writer offers an apology to the members of the Boston Society of Civil Engineers for the reports in detail of this cofferdam failure, but offers them in the belief that it is wise to have both sides of a discussion presented, and that in such a way the facts may be more clearly brought out.

DISCUSSION.

MR. CHARLES R. GOW.* — The chief feature of interest from an engineering standpoint, contained in Mr. Rollins' paper, is the behavior of the cofferdam and the probable cause of its failure.

It seems to the writer that there is a plausible explanation of this action, which fully accounts for each stage of the movement noted.

It is a well-known fact that all clay usually encountered in this vicinity is substantially impervious to water *in its natural state*, and, generally speaking, it is recognized as a stable and dependable class of soil. When, however, it is loosened by mechanical means, especially in the presence of water, its many laminations become separated and broken, and it may then absorb large amounts of moisture and become spongy or at times almost semifluid in character. The more such material is rehandled, the greater becomes this fluid tendency. The contained water of such a mass is held almost entirely in mechanical and not chemical combination, and, when an opportunity is afforded, this water will drain out of the mass, although a considerable period will be required in which to obtain complete drainage. Because of the extremely fine nature of the clay particles, they are easily carried in suspension with the water during this draining process.

The material which Mr. Rollins used for the embankment on the inside of his cofferdam was a mixture of clay and gravel, or what in its previous natural state had been a substantially impervious clay hardpan. This material was first excavated by a dredge, thus loosening its seams and particles. It was then towed to the dry-dock site and finally rehandled into place behind the cofferdam sheeting, where it was deposited in the water. As a result of these operations, the whole mass became thoroughly saturated. No difficulty was encountered in maintaining in position the clay thus deposited until the filling had progressed to a point somewhat above low tide. This portion then became alternately submerged and partially drained at each rise and

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* Charles R. Gow Co., General Contractors, 166 Devonshire Street, Boston, Mass.

fall of the tide, — the tide gates being open at this time to prevent unbalanced pressure on the dam. Whenever the clay was uncovered by the falling tide, water drained from its inclined face, carrying much of the clay with it and causing the top portion of the fill to slide and run down the inclined surface of the embankment. This tendency would account for the difficulty observed in raising the level of the fill much beyond that of the tide. When the tide gates were finally closed and the tidal action of alternately saturating and drying the exposed top portion of the clay mass ceased, there was no further movement from this cause. The placing of a large deposit of heavy riprap on top of the fill just prior to the attempt at unwatering the enclosure undoubtedly produced a tendency to displace the now semifluid clay fill just as a wet mass of concrete is laterally displaced when a large bowlder is dropped into it.

When finally the unwatering process was commenced, a progressive drainage of the exposed portion of the fill occurred. The entrained water left in the embankment undoubtedly assumed a very steep slope due to the slow draining character of the material. Meanwhile the great weight of riprap filling, which had been deposited on top of the clay, aided the latter in its tendency to slip along the line of water slope. As a result of these conditions, when the unwatering process had progressed for a depth of several feet, this mass constituting the top portion of the fill slid forward into the enclosure, leaving the sheet pile core section unsecured against the outside tidal pressure and resulted in its subsequent collapse.

The fact that the damaged section of cofferdam was reconstructed in accordance with the original design except that gravel filling was substituted for the clay and gravel embankment first used, and that the rebuilt dam is successfully fulfilling its intended purpose now that the enclosure is entirely unwatered, indicates in the writer's opinion that the character of the filling was entirely responsible for the failure.

The small quantity of leakage which now occurs in this completely unwatered enclosure calls to mind the predictions freely made during the early stages of the work that unless a core of steel sheet piling driven to ledge was adopted by the

contractors, serious leakage and probable undermining of the cofferdam structure was likely to result. This criticism of the type of cofferdam adopted by Mr. Rollins was concurred in by several prominent authorities. Such a steel pile core would have added very materially to the cost of the work, and in the opinion of many practical engineers and contractors of this vicinity would not have been successfully driven because of the unfavorable nature of the materials to be penetrated.

The assumed need of such a water cut-off was based upon the presence of sand and gravel strata in the underlying clay bed as disclosed by a few of the test borings.

In some instances these strata were undoubtedly isolated pockets having no direct connection with the tide water. Other deposits encountered may have had such a connection, but if so it is evident that they would tend to resist the free passage of tide water through their void spaces, due in part to the inevitable large loss of head occasioned by internal friction and still more to the silting action so well illustrated by the behavior of slow sand filtration beds in the purification of water supplies.

Mr. Rollins. — Some of the consulting engineers from the West predicted that the whole structure was going to slip on its foundation when finally exposed to its full pressure. I should like to ask Mr. Gow's opinion as to this possibility.

Mr. Gow. — Generally speaking, our Boston clay does not slide in the sense referred to. When exposed to the air it often "air slakes" and disintegrates at the exposed face, and if left a sufficient length of time it will in this manner finally assume a natural slope of between 45 and 60 degrees. If, however, a sufficient slope is given to the initial excavation, this action will cause no movement.

Our clays have a distinct horizontal stratification which is opposed to lateral sliding and which to a considerable degree prevents lateral upheaval such as commonly occurs in the clays of the Middle West.

The facts seem to be that the full test of this structure and its foundation has now been applied for several months without indication of weakness, and if failure was to be expected in any respect it must have occurred before this time. The longer it

now stands, the more remote becomes the possibility of any unfavorable development.

Mr. Frank W. Hodgdon.* — This work has been delayed and mixed up with many things besides engineering. In the first place, the design of the dock was started when the commission was actively engaged in work on Pier 5, which took about all of my time. Therefore, at the request of the first Commission, who started work, the Secretary of the Navy assigned Mr. DeWitt C. Webb, civil engineer, United States Navy, to come here to advise in relation to the work and render what assistance he could. Mr. Webb has practically had the direct control of the design. He has helped the Commission and myself and Mr. Barrett — who had charge of the work while I was away — very materially. He was inspector on the dry dock at Philadelphia when it was being constructed, so that he was familiar with that class of work. After the work was finally let by the Commission to Messrs. Holbrook, Cabot & Rollins, it ran along, with nothing being done, as Mr. Rollins told you. I was taken sick and had to leave, being away from the office practically a year, actually for four months, and during the remainder of the time did very little. Mr. Barrett had charge of the work during that time, the beginning of the work and the troubles with the cofferdam occurring while he was in charge. Of course he had the assistance of Mr. Spofford and Mr. Emerson as consulting engineers, although they were not consulted more than twice during the whole time. Mr. Rollins handled the work with his usual energy, and if he had had the proper materials to back up the dam I do not think we should have had any trouble with it. The greatest trouble was due to the dredging of the channel through the location on which the cofferdam was afterwards built, making the height of the dam some ten feet or more greater than was originally planned. If the contractor had had the opportunity to fill that trench (it was about 100 ft. wide on the bottom) with gravel, it would have been all right, but by putting in the soft clay from the harbor dredging, a great mistake was made. If the clay could have been placed in the

* Engineer, Massachusetts Commission of Waterways and Public Lands; formerly Chief Engineer of Directors of the Port of Boston.

condition in which it was dredged it might possibly have stood up, but after being rehandled it became like porridge and unsuitable. I have seen some of the same material after being rehandled and dumped out of cars flow off on a slope of 1 to 25, when they were trying to make it spread as far as it would by dumping. It would average that slope month after month.

Mr. Rollins spoke about the breaking of the sheeting, evidently from the internal pressure of the material filling between the walls of the cofferdam. After the break he took up a number of the planks and found them all broken almost midway of the length. The planks ran about 35 ft. in length, and it was just about 17 or 18 ft. from the upper end that they were broken. He took great care in pulling them up in order to be sure a fresh break was not made. When driving, the walls of sheet piling were held together at about high-water level by a pair of rods at each main pile and another pair of rods at each main pile at about a foot above low water. From low water down 18 or 20 ft. the planks were unsupported. At that depth they entered the stiff blue clay. When the dam gave way the washers on the rods either broke and allowed the rods to pull through the wood or they split the timber. I think the timber gave way in a great many cases. Against the great pressure from the filling between the lines of sheet piling the soft material on the outside offered practically no support. It was like pushing the planking through water. The principal lesson to be learned from the cofferdam failure was that the failure was due to its having no support from outside to resist the interior pressure, owing to the flowing character of the material forming the supporting embankment.

The original design was for a straight dock, as shown on the plan, but when Admiral Harris came he discussed the advisability of adding an intermediate sill. In the original design the filling culverts went through the main walls with the drainage culverts under the floor, but in making the change it was found more economical to have the drainage culverts act as filling culverts in order to control the water better, and it required changes in those culverts in order to conduct the water to the pumps from either section of the dock or from both sections

when the whole dock was in use. The present design calls for only one caisson with which either the interior section or the whole dock can be used, but if later business is found to warrant, by simply building another caisson the interior section can be used for a vessel docked for a long period and the outer for a vessel docked for a short period. The second sill will be of concrete, exactly like the outer sill, and will be faced with granite. One reason for using granite facing for the whole dock is that this is a granite country and we wanted to advertise the granite. The granite will increase the cost about $180 000. The original design called for the coping and the face and backs of the altars to be of granite, in two courses, one for the top of the altar and one for the back. We had another design which called for facing everything above the low-water level with granite, leaving the concrete face below, but it was finally decided to adopt the proposition to face the whole of the side walls with granite. The floor of the dock will be simply a smooth, granolithic surface. The sill will be of granite throughout. In designing the caisson, we departed to a slight extent from the usual practice in having the caisson built with a wood bearing without any rubber gasket.

One very interesting fact developed in making the investigations. The consulting engineers wanted a certain number of borings made, and we started all the plant we could get to do it, Mr. Rollins kindly using some of his well drills so that we now have six or eight 6-in. pipes driven down practically to the rock, some at the upper and some at the lower end of the dock site. We have been observing, from time to time, the rise and fall of the water in those wells. When they were first driven the water would rise and fall in them with the tide, keeping almost at the same level as the tide in the harbor but a little behind it and of course with not quite as great a range, although within a foot or two of that of the tide. But as the dock began to be pumped out we still got the fluctuation with the tide but with very much less range, and the actual elevation is going down all the time. We haven't finished our observations yet, but at every observation we have taken the level is lower; but there is still a fluctuation with each tide. The consulting engineers at first thought that this indicated a free connection with the

tide outside, and that there would be a very large flow of water into the dock. They appreciated the fact that the wells were driven near the excavation for the dock, and the water might come directly from there. When the dock was closed and the water pumped down to the level of low water, we still got the fluctuation but at a lower level, and it has continued to lower as the water has gone down. The bottom of the wells is at rock, which is generally 40 or 50 ft. below low water. There are six or eight wells, all right around the dock site. The nearest one to the water is possibly 6 or 8 ft. back from the bulkhead in the solid fill and perhaps 40 ft. outside the cofferdam. The level in that is going down, too.

Mr. Barrett. — I should like to ask who proposed driving the steel caisson well, as well as the small 6-in. wells you refer to.

Mr. Hodgdon. — What the consulting engineers wanted, in the first place, was to determine the location of the rock. This observation of the water was a secondary consideration. They wanted to determine the possibility of there being a big leakage into the excavation, but the wells were principally driven to determine the location of the rock.

Mr. Barrett. — Has the location of the rock at these points anything to do with the cofferdam?

Mr. Hodgdon. — At some of them, yes. The consulting engineers had a line of borings made on the location which they had determined upon for the cofferdam, to show the location of the rock.

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PAPERS AND DISCUSSIONS

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THE DISCHARGE INTEGRATOR.

By C. H. Pierce.*

The general use of water-stage recorders in obtaining stream-flow data has necessitated a large amount of office work for the accurate interpretation and computation of the records. As the discharge of a river is in general an increasing curvilinear function of the stage, it is evident that the average gage height for a day during which there is considerable variation in stage does not correctly indicate the average discharge for the day, and when that gage height is applied to the rating table it gives a discharge that is too small. Numerous comparisons of results obtained from computations by different methods have been made by engineers of the Water Resources Branch of the United States Geological Survey, and certain standards were adopted, with the idea of eliminating errors due to incorrect methods. For many stations it was found necessary to compute the discharge for parts of a day, the average for intervals of one, two, four or six hours being used to determine the twenty-four-hour average; occasionally the discharge hydrograph was plotted and the daily average determined by planimeter measurement. These methods of computation, though giving highly accurate results, were laborious and expensive, and effort was made to devise a mechanical instrument that would give a summation of

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values obtained from a continuous application of the rating curve to the gage-height record throughout the twenty-four-hour period.

Several engineers of the Survey have worked on this problem, and in 1915 Mr. E. S. Fuller, at that time assistant engineer, devised an instrument termed the "discharge integrator," which operates much as a planimeter operates, and contains as an essential element the rating curve of the station. Four of these instruments have been built for the use of the Geological Survey by Mr. C. H. Au, mechanical engineer, who deserves

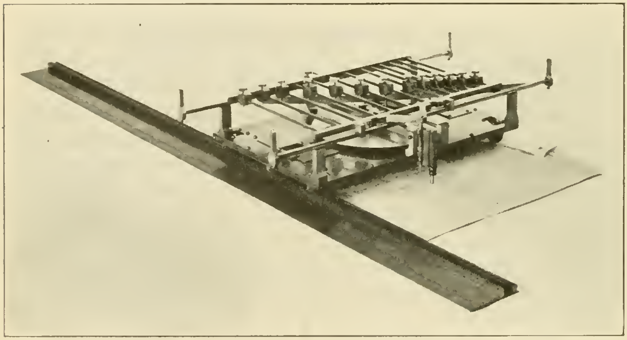

FIG. 1. DISCHARGE INTEGRATOR.

credit for working out many of the details and mechanical features. The discharge integrator in position for use is shown in Fig. 1.

The essential working parts are the rack and pinion, the transmission gears, the driving wheel, the main disk, which is rotated by the driving wheel; the recording wheel, which in turn is rotated by the disk; and the flexible curve, by means of which the recording wheel is placed at distances from the center of the disk representing the discharge at gage heights indicated by the successive positions of the pointer in its movement along the gage-height graph. The parts are so arranged that mean

daily discharge is indicated by the number of revolutions of the recording wheel when the instrument is moved along the rack a distance equal to the length of one day on the record sheet and the pointer caused to follow the gage-height graph.

The theory of the instrument is exceedingly simple, and is based on the fact that for a given distance traveled along the time scale the number of revolutions of the recording wheel is directly proportional to the distance of the recording wheel from the center of the disk, and this distance is controlled by the position of the tracing point, by means of the flexible curve which can be readily adjusted to the rating curve for any gaging station.

In operation, the base plate containing the rack is placed on the record sheet with the beveled edge of the plate parallel to the time axis. The integrator frame is placed in position on the record sheet with the driving pinion engaging the rack on the base plate. The pointer is brought to the gage-height graph at the midnight line and the recording wheel is set to zero. Then the gage-height graph is traced by the pointer for a distance representing twenty-four hours, at the end of which distance the reading on the recording wheel gives the average discharge in cubic feet per second for the twenty-four-hour period. The total length of the base plate is 36 ins., with an effective length of 27 ins. which may be traveled by the integrator for any one position of the base plate. The time required for operation varies with the character of the record and the skill of the operator, but will average from one to two minutes for a day's record. The precision obtained is much higher than that obtainable by other methods, and when ordinary care is used the results obtained by different operators usually agree within a fraction of one per cent.

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PAPERS AND DISCUSSIONS

AVIATION AS APPLIED TO THE NAVY.

By GEORGE D. MURRAY,* LIEUTENANT, U.S.N.

(Presented May 16, 1917.)

I TRUST that in our discussion of some of the problems of aircraft as applied to the navy, I may be able to suggest to your minds certain ideas and thoughts which may help you in studying the various phases of the present war pertaining to naval operations.

As the term "aircraft" does not convey a particularly clear idea to the lay mind, a few definitions should be given, in order to make clear what follows.

(*a*) "Aircraft," include lighter-than-air machines, such as balloons, air-ships or dirigibles; and heavier-than-air machines, which are termed airplanes.

(*b*) In the lighter-than-air machines, sustentation is obtained from the buoyancy of a volume of light gas. In the heavier-than-air machines, sustentation is obtained from the dynamic lift of the wings. In both cases, i.e., with lighter-than-air machines and heavier-than-air machines, propulsion through the air is obtained by means of propellers producing thrust sufficient to overcome the resistance of the air.

(*c*) The airplane when equipped with landing gear (usually wheels), to permit it to rise from the ground and alight on the ground, is commonly called a "land machine"; while the air-

* United States Custom House, Boston, Mass.

plane when equipped with landing gear (usually a float or pontoon system), to permit it to rise from and alight on the water, is generally termed a "seaplane."

To-day the importance of aircraft in land operations both for strategical and tactical purposes is keenly realized by all of us, yet the wonderful feats which are now daily occurrences over the battle fronts of Europe were but the dreams of the most visionary a few years ago. A similar condition as regards the use of aircraft in naval operations does not exist, and except for occasional dispatches reporting demonstrations against seacoast towns, stations or supply depots, little is heard regarding the use of aircraft at sea. Further, on account of the main German fleet remaining inactive, bottled up by the British navy, the development of the strategy and tactics of aircraft in naval operations has not been so marked as has been the case in land operations.

While it may appear to be a slight digression from the subject matter, I shall venture to outline briefly what is meant by naval strategy and tactics, in order that we may establish the relations which aircraft bears to them.

Strategy, briefly, involves all preparation made in anticipation of an engagement before the enemy is sighted; or, in other words, it is limited to planning and directing. It includes the following:

(*a*) The number of vessels of each type required and their characteristics.

(*b*) Location of naval bases, repair stations and their capabilities.

(*c*) War plans providing for all possible contingencies.

(*d*) Organization of the forces.

(*e*) Operations and movements of forces in the execution of policy in peace and war.

(*f*) Operations and movements of forces for the purpose of exercising and test, as in war games.

It can, therefore, be seen that strategy extends back over a long period of time before an engagement with the enemy forces is imminent, and the development of its various phases continues up to the time the fleets make contact.

Tactics, on the other hand, begin where and when strategy finishes, and cover the movements and operations of the forces while in contact with the enemy. In the study of it, not only the strength, possible movement and disposition of one's own forces in an operation must be considered, but also the strength, gun-power, disposition, course, speed and maneuvering qualities of the enemy under various conditions of wind and weather.

It therefore becomes apparent that, in the development of strategy and tactics in naval operations, the employment of aircraft is an important factor, and in the study of strategy and tactics, due consideration must be given to the presence and employment of aircraft in both forces.

It may be stated that the following duties must be performed by naval aircraft: (*a*) Scouting from ships at sea; (*b*) off-shore scouting from coastal stations; (*c*) spotting; (*d*) offensive operations against enemy aircraft and possibly against ships and stations.

Of the above, it is considered that (*a*) scouting from ships at sea is of primary importance, and it is the endeavor of the navy to develop seaplanes for this purpose.

In order to provide a seaplane that will most efficiently do the work required, i.e., to scout at sea, we must have one that possesses great speed with as low a landing speed as possible; pontoons or floats which will allow it to withstand rough usage on the water, yet light enough so that good flying qualities are not sacrificed; and of such size as will permit economical stowage aboard ship.

The development of the seaplane has been carried on for several years, and it has still a long way to go before most of the military conditions required to make it fulfill its purpose are attained. The principal reason for this is that the conditions of service that the seaplanes must meet are much harder than for land machines. In detail: first of all, we have greater weight and head resistance, which affect both the climb and the speed possible to attain; second, the difficulties of float or pontoon construction, which are enormous, since weight must be cut down, head resistance diminished, and speed, climb and maneuvering qualities in the air obtained; third, the problem of

stowage aboard ship; fourth, the problem of launching from the deck of a ship, or allowing the seaplane to fly from the surface of the sea; and lastly, the additional engine power required to get the machine off the water.

The solution of the seaplane problem is rendered more difficult because so few people really understand the many difficulties encountered. A certain amount of coeducational work of both manufacturer and user was, therefore, necessary before any real progress could be made.

Before arriving at the type of seaplane that must be used for scouting purposes at sea, many months have been spent in the development of a suitable type of training machine. This type of machine is now fairly well established as compared with other types. It necessarily is slow, with a wide range of speeds, has a reasonable climbing rate, and possesses good control and maneuvering qualities. In general, this type has about the following dimensions: Span, 40 ft.; chord, 6 ft.; gap, 6 ft.; length over all, 27 ft.; height, 10 ft.; area of lifting surface, 450 sq. ft. It is equipped with a 100-horse-power water-cooled motor, and its total weight loaded, meaning weight of the seaplane plus weight of pilot and passenger and oil and gasoline for flight of $2\frac{1}{2}$-hours' duration, is 2 300 lbs. Its maximum speed is 65 miles an hour, minimum speed 40 miles an hour and climb 2 500 ft. in ten minutes. Now compare these specifications with those of the first speed scout that is about developed. We have, in the latter type, span, 28 ft.; chord, 4 ft. 6 ins.; gap, 5 ft.; length over all, 24 ft.; height, 10 ft.; area of supporting surface, 240 sq. ft. It is equipped with a 100 horse-power water-cooled motor, and its total full load, meaning pilot, oil and gasoline for flight of $2\frac{1}{2}$ hours, is 1 500 lbs. Its maximum speed is 95 miles per hour, minimum speed 50 miles per hour, and climb 5 000 ft. in ten minutes.

In the second duty of naval seacraft, for "off-shore scouting from coastal stations," use will be made of what are termed dirigible Blimp balloons, a type of lighter-than-air craft now under construction. In its development we have been unfortunate, as most of the work has been done abroad (the knowledge on the subject in this country being very limited), resulting in

slow progress being made. The shape of the envelope, or bag, of the Blimp dirigible somewhat resembles that of a cigar. The entire length from tip to tip will be 160 ft. and the maximum diameter 31.5 ft., and the maximum width over the tail fins will be 36.2 ft. This envelope will displace 77 000 cu. ft. Suspended from the envelope will be a rigidly built car, spacious enough to carry a pilot, an observer, the necessary accessories for determining altitude, speed, etc., and a 100 horse-power gasoline motor of the latest improved type. The car used in these dirigibles will closely resemble that of the ordinary airplane, except that it is so constructed that for strategic or other reasons the pilot may light upon a body of water. This is made possible by attaching skids of ash, to which are securely fastened large waterproof cylinders of fabric stuffed with kapok fiber, which afford the requisite buoyancy. Ample room is provided in the car for the pilot and observer as well as the compact power plant, and both compartments are well protected from the weather. The total weight of the dirigible will be about 5 000 lbs. Provision is also made for carrying ballast, which, when thrown out, will enable the dirigible to reach an altitude of 7 500 ft. with safety. These dirigibles are to be so constructed that the maximum speed of 45 miles per hour may be maintained for ten hours. They can also endure sixteen hours of flying at the cruising speed of 35 miles per hour, which permits a range of 560 miles.

The third duty for aircraft to perform is "spotting." While nothing of a very exact nature concerning the employment of aircraft for spotting in the fleet can be told at this time, yet I can say the possibilities of the use of the captive balloon in connection with the spotting of shots in the control of fire are being investigated. In defensive actions, to protect a part of the coast against bombardment by an enemy, the same system of the control of the fire from the coast defense stations, by airplanes, will be used as in all the artillery actions on the European fronts.

To provide for aircraft for "offensive operations against enemy aircraft and possibly against ships and stations," a type of aircraft distinctly different from the scout is required, — one that has real offensive power. The failure of the "Zeppe-

lin " as an offensive arm is pretty generally conceded, and it is beginning to be questioned whether the heavier type of airplane, the battle-plane, mounting guns, is proving much more of a success than the Zeppelin. It is reported that the construction of battle-planes capable of carrying a live load of two guns and the equivalent weight of twenty-odd men has been pretty much abandoned.

Admiral Fiske, in a recently published article, makes some very interesting statements in regard to the battleplane and its employment as a defensive arm in the protection of the coast. He says: " In case our fleet is defeated in the Atlantic during the next year, we shall not have an army that could stand up against any European army that might land on our shores. But if we had a division of, say, one hundred battle-planes near New York, costing about three million dollars, we could certainly prevent disembarkation, transit in boats to the shore and landing of any force of soldiers, especially if the battle-planes were assisted by say, two hundred small aeroplanes, dropping bombs. Similar divisions at other points, including one at the Panama Canal, could perform similar services, and the great speed of the air-craft would enable each division to guard a long extent of coast line. A division of one hundred battle-planes could go from New York to the Capes of the Chesapeake in three or four hours. They could be equipped with 3-inch guns. The muzzle energy of one hundred three-inch guns is equal to the muzzle energy (and, therefore, destructive power) of about sixty thousand soldiers' rifles."

He further states: " That the aeroplane, and especially the battle-plane, will rapidly advance in size and power within the coming year and afterwards, is the mature belief of many aeronauts; should we not, therefore, immediately investigate its capabilities not only as a scout and accessory, but as a major instrument of warfare? "

The training of personnel has been slow, because of the lack of proper aircraft up to a comparatively recent time, with which to carry on the training. The present facilities for training are at the Naval Aeronautic Station at Pensacola, where a great many officers and men are receiving instruction. Since it is

impossible to extend the station much beyond its present capacity, other stations for the training and development of the personnel will be established along the coast. With the present system in efficient operation, it is expected that regular classes of officers and men from the navy, naval militia and coast guard can be qualified for active duty at sea in three months, and civilians with no previous training in six to eight months.

A short discussion of the various qualities and characteristics of the airplane, I hope, may not be considered out of place in closing this paper. The flight of all heavier-than-air machines is based on the following law: "Sustentation is obtained from the dynamic lift of wings, propulsion being provided by means of a propeller producing thrust sufficient to overcome the resistance of the air."

When any thin plane or cambered surface is moved through the air so that its direction of motion makes a small angle with the lower side, the fluid motion of air resulting is unsymmetrical and the resultant pressure of the air is very nearly normal to the plane of the surface. This resultant pressure or "lift" varies according to the angle at which the plane is moved through the air. It increases until a critical angle is reached called the "burble point," when it starts to diminish. On top of a wing, the surface of which is cambered, the flow of air is turbulent and the entire upper surface is under suction. This suction produces a lift which in good wings amounts to more than two thirds of the total lift. Now, in an airplane the total resultant force R expressed in pounds for a velocity V feet per second of an airplane of S square feet area can be stated as follows:

$$R = KiSV_2,$$

where Ki is a coefficient which varies in an irregular manner for different shapes of wings and for different attitudes of the same shape. By "attitude" is meant the angle at which the wing is presented to the wind. This is termed "the angle of incidence" and is arbitrarily defined as the acute angle between the wind direction and the lower chord of the wing section cut by a vertical plane parallel to the wind direction.

Now, if we express the above formula as R equals KSV_2I,

in which "K," in this case, represents the coefficient of the form of the wing, and "I" represents the particular angle of incidence, and rewrite the equation as V_2 equals $\frac{R}{KSI}$, we see that the only variable is "I," the angle of incidence. This means that for every speed of the airplane there is but one angle of incidence. Therefore, in conclusion, we may state that the speed of an airplane depends upon the angle of incidence of the wings, and the horse-power can only affect the speed through the intermediary of the angle of incidence.

DISCUSSION.

Mr. Clifford L. Webster.* — When men first started to build aeroplanes, practically every designer or experimenter had some ideas of his own on the best method of control of aeroplanes, so we have had all sorts of means of handling control surfaces. In the main, the control surfaces consisted of the vertical rudder and the horizontal rudder behind, and the ailerons or some method of twisting the wings which is the equivalent of ailerons. One man would prefer to warp his wings by foot-power and steer with a wheel and lift with the same wheel. Another man would prefer to move his ailerons with his hands and to steer with his feet. The Wright brothers worked out a system where with your right hand you pushed a lever forward and back to warp the wings, which was unnatural, working at right angles to the effect you were trying to cause; and with the left hand you had a lever to push forward and back for your up-and-down control, which gave you the two hands working sometimes in opposite directions and sometimes in the same direction, but seldom the same amount. It was something like the stunt of rubbing your stomach and patting your head. Then they gave you a little wrist motion on top of the warping lever to work your rudder with. You could work your warp and rudder together, which was the only advantage of it. The Wrights later turned out a machine in which you worked your ailerons with a wheel and then had a segment which worked the rudder. The Navy rather

* With the Burgess Co. & Curtis, Marblehead, Mass.

approved of that method, but found it was so hard to get the adjustment between the segment and the wheel correct that it was not considered advisable to retain it, and they put the control of the rudder on a foot lever, making it into the "Deperdussin" control, which is practically universal now. There is a wheel to operate the ailerons. You roll the wheel away from the wing which is too low, bringing the wing up. The steering is done by pushing the foot forward on the side to which you wish to turn, just the opposite of the little boy's go-cart. That seems to work very well in connection with the rolling wheel. The wheel is pushed forward to descend and pulled back to ascend.

In training, of which I shall probably do considerable this summer at the Squantum school which has just been opened, the general procedure is to take the pupil up in a two-passenger machine having a set of controls in each seat. On the first flight you simply give him a passenger flight of about fifteen minutes, so he can see how it feels to be in the air and permit him to get over any uncomfortable sensations he may have. On the second flight we tell the pupil to put his hands on the control and feel about the amount and direction in which they operate. Then by the third lesson he has very well in mind what he ought to do, and we let him go ahead and try to do it while the machine is flying at a considerable altitude, allowing plenty of room below, so that if he makes a mistake the instructor has time enough to grab the controls and correct it before they get uncomfortably close to the ground. Then for several lessons we just try him on that, not letting him bank very much, — possibly 15 degrees, — finding out just how much he should turn his rudder for a certain bank, keeping the machine pretty level fore and aft. I think that possibly after a matter of two hours of actual flying, comprising perhaps eight lessons in all, the average pupil has the knack of it pretty well. He can then fly around in the atmosphere well off the ground and feel quite comfortable and not get into trouble. Then we start to get off the water and bring the machine back. That is a little more ticklish work because you have to get down close to things and you find you have to act very quickly. The difference in judg-

ment of a fraction of a second may be the difference between making a good landing and smashing an aeroplane, so then the instructor really sits up and takes notice and has his hands right close to the wheel ready to grab it quickly. The pupil usually bounces the machine around on the water, a good bit in first getting it off. When he gets up he comes coasting down to the water and probably forgets that the water is there, and then the instructor has to pull the machine up before he hits the nose of it. He goes up again and then becomes a little afraid of the water. He coasts down and levels the machine about twenty feet off the water at the time it ought to land, and then the instructor has to get the machine down close to the water before it loses its speed, otherwise it settles with a bump. That is called "pancaking" the machine, which gives you a good idea of what really happens. We try the pupil on getting the machine off the water and on landing it, at the same time improving his ability in driving through the air. This flying is done, of course, in short jumps, flights of about five minutes, getting up and landing again quickly, making a series of jumps, just touching on the water. Then after a matter of possibly five hours of flying the pupil really knows how to fly the machine under good conditions. We send him out when there is a good day, and the instructor hopes he has not neglected to tell him anything. After a few flights the pupil takes his certificate, which means that somebody has seen him make a certain number of figure 8's and land the machine without smashing it within a reasonable distance of a given mark. Also that he has taken the machine up three hundred feet, shut his motor off, and glided down with a dead machine or engine. Of course the dead-engine stunt is given toward the end of the course, because with the engine off you have only one try at landing. If the power is on you can speed up and go on a little farther if necessary. If the engine stops and you get down close to the water, you must land. After the pupil has taken his Aero Club certificate and flown the machine alone, if he is going to do any more flying he starts in and really learns after that. He has just got the idea of it then. He is all right in good weather and under good conditions, but whether he would "get away with it" under unusual conditions,

no one knows, and so the Army and Navy require, before they put him to any serious work, that he should go ahead and fly by himself in various sorts of weather at various altitudes, having certain objects in view, — either cross-country flying, spiraling, circling or something else, — a matter of forty hours, more before they consider him a good pilot. When I speak of hours of flying, that means adding up the total number of short flights. A preliminary course of flying, which is between five and six hours, will probably be extended over a period of a month or six weeks, if it is bad weather.

Q. — How long a lesson do you find a pupil absorbs best?

MR. WEBSTER. — As a general thing, we think a lesson of about twelve to fifteen minutes is best. When a pupil is just starting in, anything over fifteen minutes gets to be quite tiring; so we use rather short flights. Frequently toward the end of the course a pupil will do perfectly well if you keep him going for half or three quarters of an hour, and once a man has learned to drive a machine, he can do so for hours without getting tired at all. It is like learning anything else. At first you grip the wheel like death. When you get used to the control, you can take two fingers and handle it.

Q. — What is the highest speed obtained in this country?

MR. GREELY S. CURTIS.* — I believe the highest speed was that made by a racing monoplane at Chicago some years ago, — about one hundred and twenty miles per hour or thereabouts. There have been some speed scouts built for the Army and Navy, but if they have exceeded that speed, it is still concealed by the censor.

Q. — Do you think flying will ever come into use for utilitarian purposes?

MR. CURTIS. — I took "flying" as the subject of a thesis in 1892; but every year takes off a little from my original anticipations, until now I am somewhat discouraged about its future. It seems less and less likely to develop usefully as each year passes. There are so many risks and there is so much expense. The deterioration of the motor is — I won't say a dollar a minute — but about twenty dollars an hour as a minimum, which is for

* Treasurer, Burgess Co. & Curtis, Marblehead, Mass.

the use of the motor alone, not counting repairs or anything of that kind, and that makes it a very expensive sport.

Q. — What is the cost of a medium-sized machine, such a machine as could be used in flying on land?

Mr. Curtis. — Some of the machines shown on the screen have been built for $5 000. I do not think there have been any built below that, and they run a long way above. I saw some bids for Navy specifications at $22 000 for a machine. Those are not the gigantic machines. They are for military purposes. I think the cost is apt to increase rather than decrease.

Q. — Are revolving motors used at all now here?

Mr. Curtis. — The government has quite recently placed an order for, I believe, fifty American-made rotating motors, but it came as a great surprise to us, as manufacturers. We heard they had gone out of favor on this side, and very largely on the other side, with the exception of some French motors. We have not seen any rotating motors in practical use here for a number of years. They are much less popular than they used to be, so that this order for a considerable number of them was a great surprise to us.

Q. — What is the cause of their failure, or why are they not considered as good as a stationary motor?

Mr. Curtis. — The best information we have has been that the motor can only run a limited number of hours before it has to be taken down and cleaned out. There is no lubricant known except castor oil, and that gums them up so badly they need constant taking down to clean them. They are very delicate, and are air cooled. When the Hendee Motor Company undertook to duplicate a Gnome motor, they worked for two or three seasons having an actual sample before them, and found they could not make a machine which would run satisfactorily. A company was established in Washington for making rotary motors, and each time they made a new motor they declared the new one would be better than the last. Finally they induced a foreign government to specify one of these motors in one of our aeroplanes, the sale being contingent upon the whole machine operating properly. We had it out tuning up for two months, the longest flight being, I think, about thirteen minutes,

and it never came down twice for the same reason. This indicates that a rotating motor is a very delicate mechanism. They have the secret in France. Duration records have been made with them and they have been wonderfully successful, but they do have the defects I have pointed out, — the gumming up and the necessity for taking them apart and cleaning them out. We have not been able to build them yet properly. There is also another point against them, and that is that if you are doing cross-country flying in military work you can buy anywhere the ordinary automobile oil, which is sufficiently good for the standard type of European motor, but you cannot find more than a quart of castor oil even at a drug store, and therefore you would be stuck where you landed until you could get a reasonably large supply of castor oil.

Q. — Is the center of gravity of a seaplane considerably lower than that of a landplane?

Mr. Curtis. — It depends somewhat on the individual type of machine. In some types of seaplanes the center of gravity is noticeably lower, and it makes a considerable difference. It throws out a large part of the efficiency of the Dunne principle. You can realize that if your propeller is going to be replaced by the force of gravity, the former must act in a horizontal line through your center of gravity; otherwise a shift in your control surfaces would be necessary. When gravity acts on a glide you have a force exerted along the line passing through that center of gravity. If your propeller is located above your center of gravity, there is going to be a turning moment tending to push your nose down. The minute the propeller stops, your upsetting moment forward is going to be relieved and there would be a tendency to sag back. So in the Dunne type or any other type which is going to have inherent stability, the line of propeller thrust must pass approximately through the location of the center of gravity; otherwise a pitching moment would be set up.

Q. — What is the cause of the extremely rapid deterioration in the motor that you speak about?

Mr. Curtis. — The cost of an aeroplane motor runs anywhere from \$3 000 to \$6 000. Assuming you have a high-power motor at \$6 000, three hundred hours is a pretty long life for

an aeroplane motor in actual flying. It is short for an automobile motor, but the aeroplane motor is cut right down to the limit as far as weight goes, and they do not stand up. Something essential gives way long inside of three hundred hours, as a rule. You cannot count on more than that as the life of a high-grade aeroplane motor. That is largely on account of the fact that they have to be built light, but more particularly because in flying the use of the motor is very different from that in an automobile. In an automobile you run with one quarter of your power for ordinary running, or less than that; but in an aeroplane, you have your throttle pretty nearly wide open most of the time, and clear open a good deal of the time, so that it is being driven pretty near its limit most of its life. Some of these motors are designed to run 2 600 revolutions per minute, though others with direct drive run only 1 300 to 1 400. The practice has come in of gearing down the drive from 1 800 or 2 200 R.P.M. to 1 200 R.P.M. You can imagine running 2 200 revolutions for three hundred hours with a delicate mechanism which has been pared down to the lightest possible weight.

Q. — Is there any trouble with lubricating the machine?

Mr. Curtis. — That has been one of the difficulties that all engine designers have been up against. If the motor begins to miss in an automobile you can go on until you come to a convenient garage, but if it begins to miss in the air, you come right down and do not take any chances unless you are under military orders. Mr. Webster can tell you of his experience with a Canadian officer on the St. Lawrence. The Canadians wanted a certain Burgess machine in a hurry. It was taken up to Lake Champlain, and they started to fly from there to Quebec. He will tell you what happened.

Mr. Webster. — We flew from Lake Champlain to the St. Lawrence River, a matter of ninety-odd miles, with considerable side wind, so it took an hour and fifty-five minutes. Something had worked loose, and when we landed we were very short of oil. We put in some more and some gasoline also. Probably one of the bearings had got pretty well out of oil during that time and had started to heat a little. So we went forty-five minutes down the river, covering about sixty miles. This was

in the original Burgess-Dunne machine. Then we began to notice a knocking in the machine, so we landed near shore and tried the engine and decided the knock must be in the crank-shaft or connecting rod bearings. Although I wanted to stop right there, this captain said, "No, we will go right through to Quebec." He had driven an automobile motor with a burned-out connecting rod bearing. He owned the machine, and I was willing to take a chance if he wanted to. We started up and headed down the river ahead of the wind, about ten feet off the water, without power enough to get higher, and once in a while dropping almost on to the water. The engine ran about eighteen minutes more and then the piston slid up into the countersunk portion of the head, the piston became broken squarely in two, and the connecting rod finally jumped right out through the crank case and the engine bed. There was considerable noise aft and we landed and drifted until they towed us ashore.

Q. — Are most of the military planes biplanes?

Mr. Curtis.— Practically all. There are no monoplanes so far as I have heard in use by the United States War or Navy departments. They use them on the other side, but they are in a minority. For almost all work they are using biplanes. The latter have a greater capacity and wider range of speed and are better adapted for military uses than the monoplanes, that is, so far as the experience of this war has indicated.

Q. — What is the advantage of having propellers in front as compared with having them in the rear?

Mr. Curtis. — The propeller in front necessarily implies that your motor is in front. If you are flying over land, it is considered by the authorities safer to have your motor land first rather than behind you, because in case of a rough landing it might otherwise get jarred off and fall on you. That is one of the safety reasons. Also you propeller is working in undisturbed air when it is in front. Another very essential feature is that if your motor is behind you will have to build up a framework to carry your tail surfaces, and that framework offers a very considerable resistance to the air and will slow you down. Consequently the pusher type of machine is several miles slower than the tractor type, using the same wing surfaces and the

same motor. So you gain in efficiency and add somewhat in safety by placing your propeller in front.

Prof. Edwin B. Wilson.* — The theory of the aeroplane, so far as we know it, has been almost all made in England, owing to the excellent training they give in theoretical mechanics, which is, of course, a sort of specialty in England, and has been since Isaac Newton's time. There are a great many things about theoretical mechanics which are not ordinarily considered "practical," and which are not yet taught very much in this country, although the theory of the aeroplane will probably soon demonstrate that they must be more widely taught.

In the early days of the theory of the aeroplane there were quite a number of papers written in France, involving some little trigonometry or something like that, but nothing very complicated or that got very far on the dynamical problem of motions. So far as statics of the aeroplane are concerned, they did very well, but the great question in the theory of the aeroplane is not the statical feature, but the dynamic stability. There is a difference, of course, between dynamic stability and static stability. Dynamic stability is illustrated very well in that Dunne type. If the machine is moving and gets off a steady condition of flight, it tends to come back of itself to that steady condition. A machine may be statically stable and not so dynamically. That is to say, if it gets off its path when at rest, and there is a righting movement tending to bring it back, it is statically stable, but the righting moments may not operate in detail on a moving machine just as they seem to when examined on the machine at rest.

We therefore have to consider the machine as moving in a uniform line parallel ordinarily to the surface of the earth. If slightly disturbed from that, the machine takes up of itself an oscillatory motion, and if the machine is dynamically stable, the oscillation will die out; if the machine is not dynamically stable, the oscillation will not die out. It is not absolutely essential that you should have dynamic stability, but you must not have too serious a degree of dynamic instability or there will be trouble. For instance, the Curtis tractor JN–2 is slightly

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unstable. If it gets off its path it will not come back, but it does not diverge very rapidly so that it is sufficiently stable for practical purposes.

The mathematical theory is entirely a theory of approximations. There is no way of taking into account the motion of the machine in flight under complicated conditions. For instance, I have tried for three years to tell how a machine goes around the loop. I waste twenty-five or thirty hours every now and then, and finally I give it up again. That is just on account of the complication of the problem. Those things which we can handle are relatively simple things, such as the effect on the machine of meeting a stratum of air in which conditions are slightly different from the one in which the machine has been flying. We can thus take some account of the effect of gusts on machines.

The great advances which must have been made in England since the beginning of the war are absolutely unknown in this country. I wrote to Mr. Bairstow, who is at the National Physical Laboratory in England, and asked him if there was any way I could get any information as to what they had accomplished since the war began, because I wanted to use it in my courses at the Institute. He said he would trust me with it, but could not send it on account of the censor, who would not let him send the information or allow him to write about it. The censors have let out a few articles by Professor Bryan in Wales. He has treated of motion in circular flight. The censors let that out. I suppose that is the same as saying the information is not of much immediate practical use. I cannot imagine any other interpretation. But there is the problem, that of circular flight, — one of the most common maneuvers. There is not in print anywhere a practical account of what the aeroplane does in a circular flight, — what different kinds of balance must be had. Engineers can guess at it, and pilots can put the machine through the maneuvers, but whether a machine which is theoretically stable on a horizontal flight remains so for circular flight is not yet worked out properly.

We are all waiting to get some information from England in order to improve our own knowledge and our courses an aero-

plane theory. I suppose they have done some things in France, but before the war we got nothing much except trigonometry out of France. The English were the ones who started it, Professor Bryan in England being the real pioneer, helped by Mr. Harper, who has since been killed in the flying service. There have been, I think, some articles published in Russia, but Russian literature does not get into this country very much, so that, as I say, we are dependent on the accounts of the British government in the annual reports of the National Advisory Committee, and as those stopped coming out two or three years ago, we theorists are all in the dark. Meanwhile our engineers are going on making great progress, as they generally do, away ahead of the theory.

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PAPERS AND DISCUSSIONS

DIAGRAMS FOR CONTINUOUS BEAMS OF UNEQUAL SPANS.

By Frank S. Bailey,* Member Boston Society of Civil Engineers.

It is well known that shears and bending moments in continuous beams of several spans vary considerably from those in simple beams of one span, and diagrams showing shears and bending moments for continuous beams of equal spans are to be found in various textbooks. It not infrequently happens, however, that the architectural designs for a building call for continuous beams of unequal spans, and very little data are to be found showing the shears and moments for such cases.

The maximum positive bending moment in a uniformly loaded simple beam occurs at the center of the span, and this is approximately true of continuous beams of equal spans. In continuous beams of equal spans, a negative moment exists over the intermediate supports, and, if the end spans are fixed, at the end supports as well.

With uniformly loaded continuous beams of unequal spans, the above statements do not hold true; in fact, it sometimes happens that a positive moment occurs over a support and a negative moment at the center of the span. Furthermore, in

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Note. This paper will not be presented at a meeting of the Society, but discussion is invited, to be received by W. L. Butcher, Editor, 14 Beacon Street, Boston, before December 10, for publication in a subsequent issue of the Journal.

the case of equal spans, the negative moment seldom extends to more than one fifth or one fourth the length of span from the support, and reinforcing steel in the top of the beam, to provide for negative moment, is not required for more than this distance from the support, i.e., one fifth to one fourth the span length. With unequal spans, however, the negative moment may extend over the whole span length, and steel is needed in the top of the beam for its entire span. Also in regard to the reactions at the supports: with two equal spans with supported ends the reaction at the middle support is five eighths, or 62.5 per cent., the whole load on both spans, but with two unequal spans (such as shown in Fig. 2A), the reaction at the central support is about 69 per cent. of the whole load. It is useful to know such a fact, especially when girders are used for the support of continuous beams.

It is evident, therefore, that diagrams showing shears and moments for several common cases of unequal spans with uniform loads per linear foot should be of considerable value to structural engineers, and a few such diagrams are here shown. They were prepared only after a search of the literature of the subject failed to disclose the desired information. They were computed from the formulas of the "three-moment theorem" which was originally derived by Clapeyron, demonstrations of which may be found in Lanza's "Applied Mechanics," Church's "Mechanics of Engineering," Merriman and Jacoby's "Roof and Bridges," and other treatises to which reference may be made for more complete data.

A brief description of the diagrams follows:

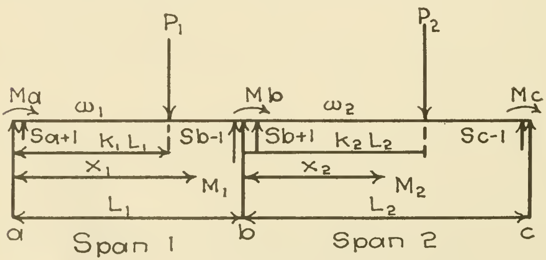


FIG. 1. CONTINUOUS BEAMS WITH UNEQUAL SPANS.

$$MaL_1+2Mb(L_1+L_2)+McL_2=$$

$$-\frac{L_1^3w_1}{4}-\frac{L_2^3w_2}{4}-P_1L_1^2(k_1-k_1^3)-P_2L_2^2(2k_2-3k_2^2+k_2^3).$$

$$Sa+1=\frac{Mb-Ma+\dfrac{w_1L_1^2}{2}+P_1(1-k_1)L_1}{L_1}.$$

$$Sb-1=\frac{Ma-Mb+\dfrac{w_1L_1^2}{2}+P_1(k_1L_1)}{L_1}.$$

$$Sb+1=\frac{Mc-Mb+\dfrac{w_2L_2^2}{2}+P_2(1-k_2)L_2}{L_2}.$$

$$Sc-1=\frac{Mb-Mc+\dfrac{w_2L_2^2}{2}+P_2(k_2L_2)}{L_2}.$$

$$M_1=Mb+(Sb-1)(L_1-x_1)-w_1\frac{(L_1-x_1)^2}{2}.$$

$$M_1=Ma+(Sa+1)x_1-\frac{w_1x_1^2}{2}-P_1(x_1-k_1L_1).$$

$$M_2=Mb+(Sb+1)x_2-\frac{w_2x_2^2}{2}.$$

$$M_2=Mc+(Sc-1)(L_2-x_2)-w_2\frac{(L_2-x_2)^2}{2}-P_2(k_2L_2-x_2).$$

$\left.\begin{matrix}Ma\\Mb\\Mc\end{matrix}\right\}$ = Moments upon beam at three adjoining supports.

$Sa+1$ = Shear at infinitesimal distance to right of support at a.
$Sb-1$ = Shear at infinitesimal distance to left of support at b.
$Sb+1$ = Shear at infinitesimal distance to right of support at b.
$Sc-1$ = Shear, etc.
w_1 and w_2 = Uniform loads per foot on Spans 1 and 2.
P_1 and P_2 = Concentrated loads on Spans 1 and 2.
k_1L_1 and k_2L_2 = Distances from supports to concentrated loads.
M_1 = Moment at section in Span 1 at distance x from support.
M_2 = Moment at section in Span 2 at distance x_2 from support.

NOTE. If k_1L_1 is greater than x_1 the expression for M_1 changes to $M_1 = Mb + Sb-1(L_1-x_1) - w_1\dfrac{(L_1-x_1)^2}{2} - P_1(k_1L_1 - x_1)$; a corresponding change occurs in M_2 if x_2 is greater than k_2L_2.

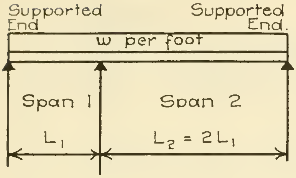
Fig. 1 shows the meaning of the various symbols in the formulas.

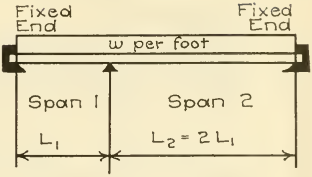
P_1 and P_2 represent concentrated loads, and are given so that other conditions of loading besides that shown in the diagrams may be investigated. They were not used in calculations for the diagrams, which are based on uniform loading alone. In calculations for uniform loading only, P_1 and P_2 each equal zero, and the terms in which they are present of course become zero. Tables giving the values of the terms $k_1 - k_1^3$ and $2k_2 - 3k_2^2 + k_2^3$ are given in Vol. 4 of Merriman and Jacoby's "Roofs and Bridges" and in Vol. 2 of Hool's "Reinforced Concrete Construction."

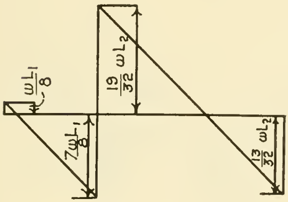
Fig. 2A shows shears and moments for two spans, one of which is half as long as the other, with ends supported. In this case it is seen that a negative moment exists over three fourths the length of the shorter span measured from the central support. Steel reinforcement in the top of a concrete beam should, therefore, extend at least this distance. This is the case previously referred to where the reaction at the central support (which is the sum of the shears immediately to the right and left of the support) amounts to 69 per cent. of the whole load on both spans. The high negative moment $\left(\frac{wL_1^2}{2.7}\right)$ in the short span at the central support is an important feature.

Fig. 2B shows two spans, one of which is half the length of the other, with fixed ends. Ends are considered fixed when they are monolithic, with heavy walls or columns. A peculiarity of the case shown in Fig. 2B is that the bending moment at the end of the short span is zero. Generally, where the ends are fixed, a negative moment exists over the end support. The occurrence of a zero moment at the end in this case is due to using span lengths of the particular ratio shown. In the case of three spans shown in Fig. 3, if each of the end spans were made slightly more than one half the length of middle one, a ratio of length could also be found where there would be a zero moment for the ends of the fixed spans.

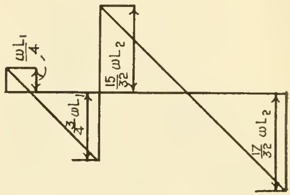
Fig. 3 shows the curves for three spans, each of the end spans being half the length of the middle span. In this case



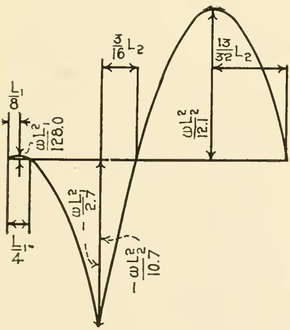




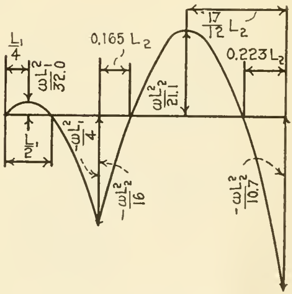
Curve of shears for uniform load $= w$ per foot over both spans.



Curve of shears for uniform load $= w$ per foot over both spans.



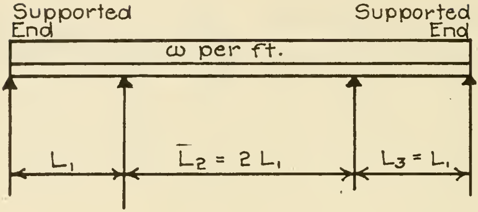
Curve of moments for uniform load $= w$ per foot over both spans.

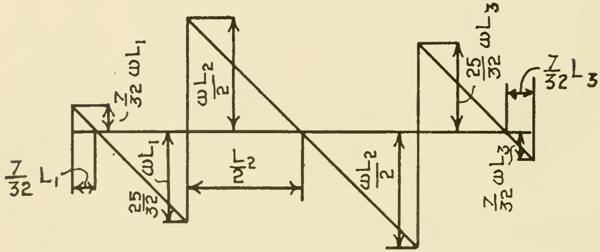


Curve of moments for uniform load $= w$ per foot over both spans.

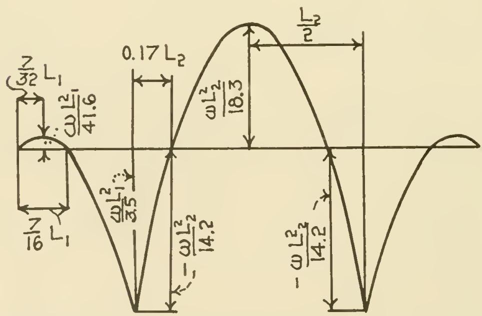
FIG. 2A. FIG. 2B.

UNIFORMLY LOADED CONTINUOUS BEAMS WITH UNEQUAL SPANS.





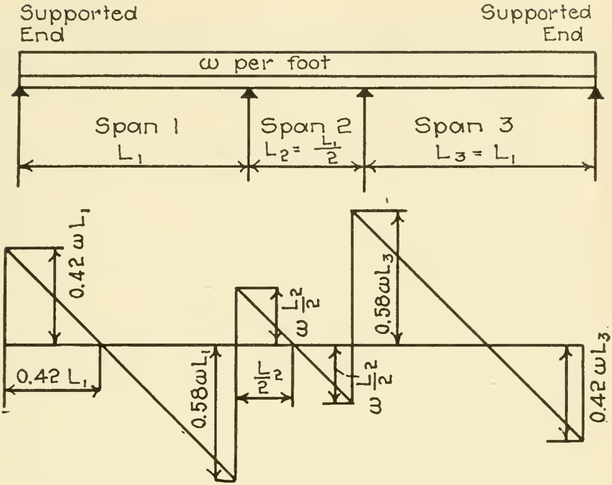
Curve of shears for uniform load $= w$ per foot over three spans.



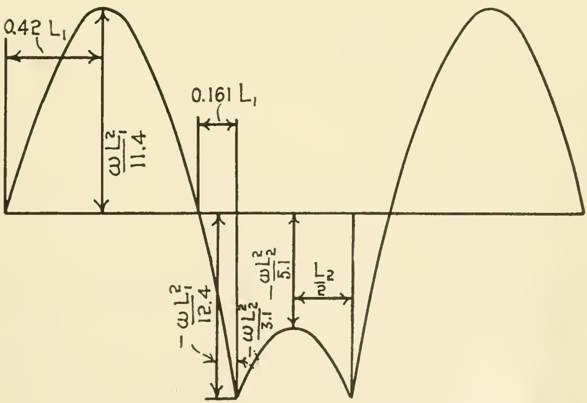
Curve of moments for uniform load $= w$ per foot over three spans.

NOTE. With span lengths as shown in this case, and with uniform load, the shear and moment curves for fixed ends are practically the same as for supported ends.

FIG. 3. UNIFORMLY LOADED CONTINUOUS BEAMS WITH UNEQUAL SPANS.



Curve of shears for uniform load $= w$ per foot over three spans.



Curve of moments for uniform load $= w$ per foot over three spans.

FIG. 4. UNIFORMLY LOADED CONTINUOUS BEAMS WITH UNEQUAL SPANS.

it is noted that the curves for fixed ends are almost identically the same as for supported ends. As a matter of fact, it was found that a small positive moment existed over the end supports where the ends were fixed.

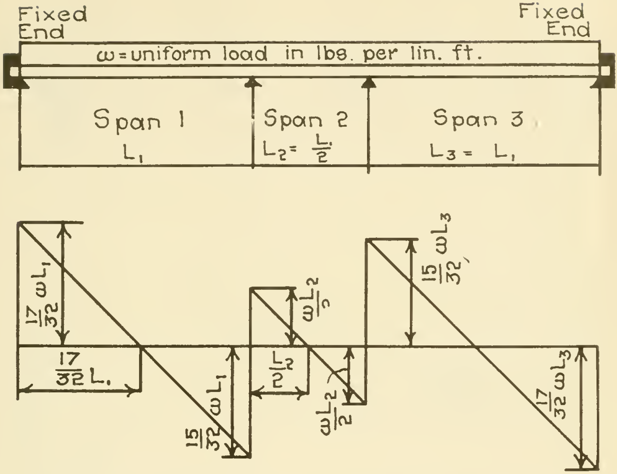
Fig. 4 shows curves for three spans with supported ends, with each of the end spans twice the length of the middle span. It is especially interesting as a case in which there is no positive moment in the middle span, — a negative moment of $\frac{wL_2^2}{5.1}$ existing at the center of the span. In this case it is evident that the top of the beam should be reinforced with steel for its entire length to provide for the negative moment.

Fig. 5 shows the same span arrangement as Fig. 4 but with fixed ends; the same phenomenon with regard to negative moment occurs in the middle span as was observed in Fig. 4, but to a less amount.

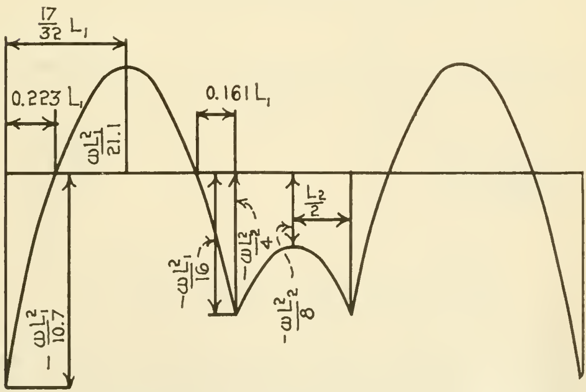
Nearly all authorities recommend using $\frac{wL^2}{12}$ for moment at center and support for interior spans and $\frac{wL^2}{10}$ for center and support for end spans, and perhaps the most striking feature of the diagrams is the information they give as to the high negative moments at the support (and in some cases throughout the entire length of the short span), amounting in one extreme case to $\frac{wL^2}{2.7}$.

In practice this does not affect the design so much as these figures would appear to indicate, for the steel in the top of the beam over the support is, or should be, proportioned to the negative moment for the longer span, and this amount is extended into the short span, thus giving a sufficient amount of steel for the moment in the short span, provided it is extended far enough.

Fig. 6 shows shears and moments for a beam with fixed ends and triangular loading. Mr. W. W. Clifford, member of Boston Society of Civil Engineers, became interested in this problem, and after finding several different solutions which did not agree he enlisted the writer's efforts. To Mr. Clifford belongs the credit for first finding the correct solution. The

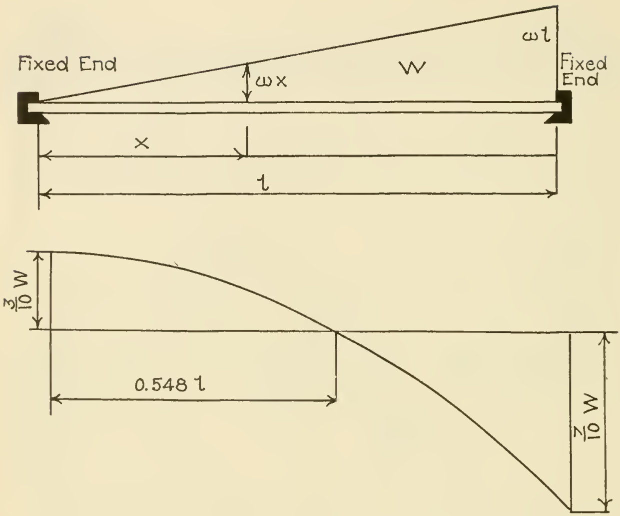


Curve of shears for uniform load = w per foot over three spans.

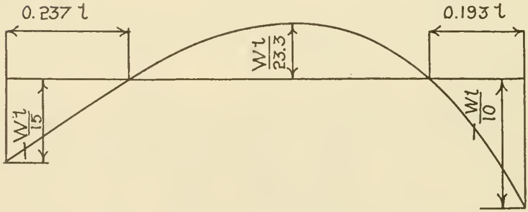


Curve of moments for uniform load = w per foot over three spans.

FIG. 5. UNIFORMLY LOADED CONTINUOUS BEAMS WITH UNEQUAL SPANS.



Curve of shears for triangular load $= wx$ per foot.



Curve of moments for triangular load $= wx$ per foot.

FIG. 6. TRIANGULAR LOADED BEAM WITH FIXED ENDS.

method he used was to take Merriman's factors $(k-k^3)$ and $(2k-3k^2+k^3)$ and with $kl=x$ then assume that a concentrated load wx was applied over each infinitesimal portion of the total length of the beam. The integration gave the follow-

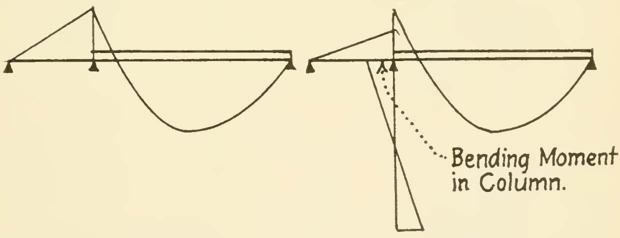
ing equation: $M_1l_1+2M_2(l_1+l_2)+M_3l_3=-\frac{2}{15}w_1l_1^4-\frac{7}{60}w_2l_2^4$. The writer checked this result both by Mr. Clifford's method and by following the method given in Lanza's "Applied Mechanics." (See Appendix.)

NOTE.* In actual design for uniform loading, the formulas $\frac{WL}{10}$ for end span and $\frac{WL}{12}$ for interior spans should be used for positive moments, and $-\frac{WL}{10}$ over end supports and $-\frac{WL}{12}$ for interior supports, except where the diagrams indicate the existence of larger negative moments.

In Fig. 3 the bending moment at the wall column is zero, which is caused by the fact that the negative bending moment in the end span, due to the fixity, is taken up by the positive bending moment caused by the loads in the interior span. If the interior panel is not loaded of course the negative bending moment will occur at the wall support and, therefore, must be provided for.

The curves show the theoretical bending moments.

The actual bending moments will be different because not

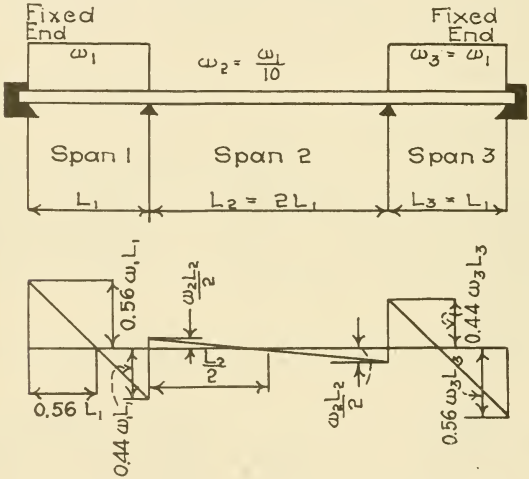


Theoretical. Actual.

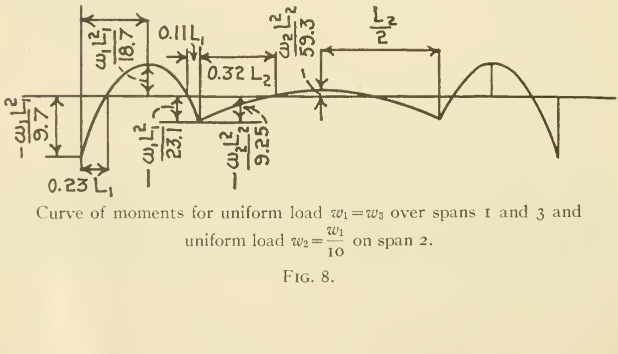
FIG. 7. THEORETICAL AND ACTUAL BENDING MOMENTS.

* The above note is appended at the suggestion of Mr. Sanford E. Thompson. Mr. Thompson's article, "Design and Construction of the Massachusetts Institute of Technology," in the *Journal American Concrete Institute*, July, 1915, contains some useful data on the subject. It was unknown to the writer until some time after this article was prepared. The article, "Design of Wall Columns and End Beams," by Edward Smulski, which is in the same number of the Journal referred to, is also of interest.

all of the bending moment is transferred from one span to the adjoining span, a good deal being taken up by the column. The effect of one span upon another, therefore, in actual construction, is not as pronounced as would appear from the theory. The sketch (Fig. 7) shows approximately the difference between the theoretical and actual bending moments.



Curve of shears for uniform load $w_1 = w_3$ on spans 1 and 3 and uniform load $w_2 = \frac{w_1}{10}$ on span 2.



Curve of moments for uniform load $w_1 = w_3$ over spans 1 and 3 and uniform load $w_2 = \frac{w_1}{10}$ on span 2.

Fig. 8.

Fig. 8 was prepared to show the effect mentioned by Mr. Thompson of having a light load on the middle span. Comparing it with Fig. 3, it is seen that when the uniform load per foot on the middle span is one tenth of the load per foot on the end spans, there is a very great change in the shears and bending moments in the end spans, the most noticeable features being the great increase in the shear and negative bending moment at the end supports.

APPENDIX.

By first method. Taking two spans of equal length with equal triangular loading beginning at zero at the left of each span and increasing uniformly to a maximum at the right of each span, then, for a single concentrated load—

$$M_a l_1 + 2M_b(l_1+l_2) + M_c l_2 = -Pl_1^2(k_1-k_1^3) - Pl_2^2(2k_2-3k_2^2+k_2^3).$$

As $kl=x$ and there is assumed to be an infinite number of concentrated loads each equaling wx over the whole length, the above equation becomes

$$M_a l_1 + \text{etc.} = -w\int_o^{l_1}\left(k_1 l_1^2 x_1 - \frac{k_1^3 l_1^3 x_1}{l_1}\right)dx -$$

$$w\int_o^{l_2}\left(\frac{2k_2 l_2^3 x_2}{l_2} - \frac{3k_2^2 l_2^3 x_2}{l_2} + \frac{k_2^3 l_2^3 x_2}{l_2}\right)dx.$$

$$= -\frac{w}{l_1}\left[\frac{l_1^2 x^3}{3} - \frac{x_1^5}{5}\right]_o^{l_1} - \frac{w}{l_2}\left[\frac{2l_2^2 x_2^3}{3} - \frac{3l_2 x_2^4}{4} + \frac{x_2^5}{5}\right]_o^{l_2}$$

$$= -\frac{2wl_1^4}{15} - \frac{7}{60}wl_2^4.$$

By second method, using Lanza's notation—

$$m_1 = \frac{wl^3}{6} \qquad m_{-1} = \frac{wl_{-1}^3}{3}$$

$$n_1 = \frac{l_1^2}{2EI} \qquad n_{-1} = \frac{l_{-1}^2}{2EI}$$

$$q_1 = \frac{l_1^3}{6EI} \qquad q_{-1} = \frac{l_{-1}^3}{6EI}$$

$$V_1 = \frac{wl_1^5}{120EI} \qquad V_{-1} = \frac{wl_{-1}^5}{30EI}$$

$$M_2\left(\frac{l_1}{6EI} - \frac{l_1}{2EI}\right) - M_3\frac{l_1}{6EI} - \frac{wl_1^4}{36EI} + \frac{wl_1^4}{120EI} + M_2\left(\frac{l_{-1}}{6EI} - \frac{l_{-1}}{2EI}\right)$$

$$-M_1\frac{l_{-1}}{6EI} - \frac{wl_{-1}^4}{18EI} + \frac{wl_{-1}^4}{30EI} = 0;$$

therefore

$$-M_2\frac{(l_1+l_{-1})120}{360}-\frac{M_3l_160}{360}-\frac{M_1l_{-1}60}{360}-\frac{7wl_1^4}{360}-\frac{8wl_{-1}^4}{360}=0;$$

and

$$M_1l_{-1}+2M_2(l_1+l_{-1})+M_3l_1=-\frac{8wl_{-1}^4}{60}-\frac{7wl_1^4}{60}=0.$$

In this method the expression for unit load is $w(l_{-1}-x)$ for the first span and wx for the second span. The expression for m is $\int_o^x\int_o^x w(l_{-1}-x)dx^2$ or $\frac{l_{-1}x^2}{2}-\frac{x^3}{3}$ for the first span and $\int_o^x\int_o^x wxdx^2$ or $\frac{x^3}{6}$ for the second span. The expression for $V_{-1}=\int_o^{l_{-1}}\int_o^x\frac{mdx^2}{EI}$, therefore, becomes $\frac{wl_{-1}^5}{30EI}$ for the first span, and $V_1=\int_o^{l_1}\int_o^x\frac{mdx^2}{EI}$ becomes $\frac{wl_1^5}{120EI}$ for the second span.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

CLASSIFICATION OF CIVIL ENGINEERS UNDER THE CIVIL SERVICE RULES.

REPORT OF THE COMMITTEE.*

To the Board of Government,
Boston Society of Civil Engineers:

Gentlemen, — The special committee on Civil Service of the Boston Society of Civil Engineers, appointed at the request of the chief examiner of the Massachusetts Civil Service Commission, in accordance with the vote of the Society on October 18, 1916, begs leave to submit the following report.

Purpose of the Committee.

The chief examiner, in his letter requesting the coöperation of the Society, stated:

"The Commission would be pleased to have your Society appoint a committee to go into the question of the classification of civil engineers, as it exists at present under Civil Service rules, to suggest such modifications and changes as would make for the maximum of practicability, simplicity and, in a word, adequacy."

It was apparent that this was an opportunity for the Society to be of service both to the state and to the engineering profession.

* At a meeting of the Board of Government, held September 19, 1917, this report was accepted and the Secretary was directed to forward the same to the Civil Service Commission.

Work of the Committee.

As the state Civil Service examinations for engineering positions are usually held annually in December, and as changes in the Civil Service rules must receive the approval of the Governor and Council and be published at least sixty days before going into effect, it was not possible for the Society to take any action which would have become effective at the examinations last December. Accordingly, the committee has deemed it wise to take ample time for mature consideration of the subject, with a view to presenting its report in season to have its recommendations, if accepted by your Board and by the state authorities, take effect prior to the holding of the engineering examinations in December next.

Seven meetings have been held, the first on November 28, 1916, and the last on the date of this report.

The first meeting was a conference between the committee and the chief examiner and the special civil engineer examiners of the Civil Service Commission; at this conference the committee was enlightened as to the present rules and regulations governing engineers in the classified service of the Commonwealth and its municipalities, and as to difficulties experienced under the present system.

At the second meeting, on December 12, the views of engineering employees within the Civil Service were presented by representatives of the Public Service Engineers' Association of Massachusetts, an organization including about three hundred civil engineers in state and municipal employment.

At the third meeting, on February 13, 1917, representative heads of state and municipal engineering departments were present, and expressed their views regarding the workings of the present Civil Service rules and regulations and made valuable suggestions for modifications of the same.

Through the chief examiner the committee was supplied with voluminous data consisting of copies of rules and regulations, annual and special reports and typical examination papers relating not only to Civil Service work in this Commonwealth, but also to that in the states of New York, Illinois, Wisconsin and California, and the cities of New York, Philadelphia

and Chicago. Particular attention has been given to the report made to the Massachusetts legislature in January, 1916, by the Commission on Economy and Efficiency concerning the standardization of grades and compensation in the civil engineering service of the Commonwealth, as proposed in House Bill No. 349 of 1915 (House Doc. No. 1673 of 1916).

The fourth and subsequent meetings of the committee have been devoted to consideration of the information and the data thus obtained, to further conferences with the chief examiner and with the special examiners, and to the preparation of this report.

Faults of the Present System.

The provisions of the Civil Service were extended to cover civil engineers in municipal service on February 15, 1897, and in state service on March 1, 1902. The present regulations governing this service became effective in March, 1912. While much may be said in commendation of the inclusion within the Civil Service of the engineering forces of state and municipal departments and of the benefits that have since been gained, it is apparent to your committee that the system has not yet reached its maximum of usefulness, and that it has often failed, in competition with private employment, to attract or to retain engineers of thorough training and wide experience.

The committee believes that unless something is done to make this public service more attractive to graduates of technical schools and to engineers of proven ability, there is a danger that the personnel of the engineering staffs in the public service in this state will, as a whole, fall backward, rather than advance.

Some of the faults of the present system which your committee believes should be remedied are specifically as follows:

1. *Provisional Appointee.* "Present Civil Service regulations allow of provisional appointments, and these appointees, if employed continuously for one year, are rated as permanent and are not required to take examinations." (House Doc. No. 1673 of 1916, p. 6.) It appears that under Rule 6, Class 27, of the existing Civil Service rules, a rodman may be provisionally appointed at a salary slightly in excess of $300 a year, for the

reason that no one who has passed the rodman's examination and whose name is on the eligible list is willing to accept a position at the salary offered. If rated as permanent after a year's provisional service, it is possible for this rodman to be advanced in rating and pay until his salary reaches the maximum figure of $1 500 per year, *without any examination whatever.* The door is thus opened to the appointment to the engineering service of persons without engineering training of any sort, and they may remain in the service without examination until they reach a compensation and position which should carry some degree of engineering responsibility.

2. *Certifications for Municipal Appointment from Local Lists Only.* Although the Civil Service is a state-wide institution, there is, in addition to the state eligible list, a local eligible list for each municipality. If the appointing officer in any city desires to make an appointment, names are certified by the Civil Service Commission from the local list, if, and to such an extent as, names may be available thereon. In the case of engineering positions in cities outside of Boston, — and occasionally this is true for Boston itself, — it is a common occurrence either that there will be no local eligible list or that the list will be insufficient to supply the requisite number of names to give the appointing officer his choice in appointment. In such a case it sometimes happens that the appointing officer will request that names be certified from the state list, which is permissible, but more often the appointing officer exercises his right of provisional appointment from outside the list. In cities outside of Boston, it is seldom that an appointment to a higher engineering position is made from the Civil Service list, because the local list is inadequate to supply the demand.

3. *Credit Allowed for Experience.* At present too little weight is given to the experience of an applicant who takes the engineering examinations. Under the present rules, in the case of rodmen and instrumentmen, experience is marked on a basis of 5 points out of a total of 16 points or 31 per cent. of the total rating, while for junior and senior assistant engineers experience is weighted at only 5 points out of a total of 18 points, or only 28 per cent. of the total mark. It will thus be seen that actually

less credit is given for experience in the higher grades than in the lower. Your committee believes that the higher the grade the greater should be the weight given for experience, and that the present system does not fairly rate engineering applicants in the higher grades.

The committee believes that where so large a proportion of the total mark is based on the result of written examinations, there is a tendency for young engineers, fresh from school, to be given too high a rating, while older and more experienced engineers, more or less rusty on book knowledge, may be given too low a rating. The low weight given to experience as compared with the high weight assigned to written examinations is doubtless a factor which deters older engineers with considerable experience from taking the Civil Service examination. In other words, the present rule in this particular is not one which tends to secure the best men.

4. *Dropping of Names from Eligible List.* At present, " No person shall remain eligible for more than two years upon any eligible list unless the Commission shall by vote continue the eligibility beyond said period " (Rule 18, Section 3). So far as engineering positions are concerned, your committee is agreed that the interests of the service will be advanced if engineers are retained on the eligible list for a substantially longer period than two years.

5. *Specialists in Engineering Work.* Testimony has been presented to the committee which would indicate that in past years the Civil Service Commission has at times failed to appreciate the degree of specialization in the higher grades of engineering work, and has certified names of engineers for the higher positions for which their training and experience have not specially qualified them, to the exclusion of engineers lower down on the list whose special training has been along the lines in question. It is believed, however, that the need of engineering specialists is generally recognized by the Commission at the present time, and that this fault has been largely, or wholly, rectified.

6. *Investigation of Applicants for Examination.* The examining force of the Civil Service Commission, as at present

constituted, is inadequate properly to follow up and investigate the experience sheets of applicants for examination for engineering positions. The chief examiner is to be congratulated upon the work which he is doing in this direction with the very limited means at his disposal.

7. *Standardization of Salaries.* A fault of the present system, according to the testimony of representatives of the engineering employees, is the lack of standardization in salaries of engineering positions in both the state and municipal departments. After careful consideration, your committee has decided that inasmuch as this is a matter which doubtless can only become effective through legislative action, and as the work of your committee is limited to a consideration of the Civil Service rules and regulations which may be modified by the Civil Service Commission with the consent of the Governor and Council, it is not within the committee's province, or desirable at this time, to undertake the study of the standardization of engineering salaries in state and municipal departments.

Recommendations.

The committee recommends that such modifications of the present Civil Service rules and regulations be made as may be necessary to conform to the following recommendations:

1. *Classification.* The present classifications, especially as regards rodmen and instrumentmen, seem confusing and unsatisfactory. The classifications along the lines formerly in force appear preferable. The following grades for engineers and for draftsmen are recommended:

Grade A. Rodmen with pay up to $900, inclusive.

Grade B. Instrumentmen with pay over $900 and not exceeding $1 400.

Grade C. Junior assistant engineers with pay over $1 400 and not exceeding $1 900.

Grade D. Senior assistant engineers with pay over $1 900.

Grade E. Junior draftsmen with pay up to $900, inclusive.

Grade F. Senior draftsmen with pay over $900 and not exceeding $1 600.

Should the above classifications and pay rates be adopted by the Civil Service Commission, provision should be made that those now serving in grades corresponding to the new grades above named but with salaries in excess of the proposed new upper limit in each case shall automatically be placed in the grade corresponding with the salary which they now receive.

2. *Qualifications for Examination and for Promotion.* The qualifications required for original examination and for promotion should be identical and as follows:

(*a*) For Grade A (rodman) or Grade E (junior draftsman), at least one year's good practical experience; or (2) the successful completion of one year's study at a school of engineering of recognized reputation authorized by law to confer degrees.

(*b*) For Grade B (instrumentman) or Grade F (senior draftsman) at least three years' good practical experience; or (2) graduation from a school of engineering of recognized reputation authorized by law to confer degrees, plus one year's good practical experience; or (3) the successful completion of two years' study at such a school, plus two years of good practical experience.

(*c*) For Grade C (junior assistant engineer) five years' good practical experience; or (2) graduation from a school of engineering of recognized reputation authorized by law to confer degrees, plus two years' good practical experience.

(*d*) Grade D (senior assistant engineer) at least eight years' good practical experience; or (2) graduation from a school of engineering of recognized reputation authorized by law to confer degrees, plus four years of good practical experience.

3. *Experience Sheet.* Every applicant for examination for any engineering position should, as at present, file with the Commission an experience sheet according to a form furnished by the Commission, which experience sheet should be sworn to.

The experience sheet should be filled out in minute detail, especially in the case of applicants for examination for the higher positions, and in all cases should be in such form as to determine the applicant's experience as fully as possible. It is believed that the Civil Service forms should properly be revised and amplified. Each experience sheet should contain a list of references and also a complete list of former employers.

4. *Investigation of Experience Sheet.* The applicant's statements in his experience sheet should be carefully verified, and if possible further information obtained as to his ability, character, habits and personality by communication not only with the references and former employers named by him, but also with others who may be acquainted with the applicant and his work. Such investigation will necessitate not only extensive correspondence, but also personal interviews in many cases. It being apparent that, at the present time, the Civil Service Commission does not have the organization necessary adequately to investigate experience sheets, the committee recommends that a trained investigator be added to the Commission's staff, to do this follow-up work in a thorough and proper manner.

5. *Character of Examination.* The applicant's standing in examination should be determined as at present, both from his experience sheet and from written tests. It has been suggested to the committee that for the highest grade (senior assistant engineer) the written examination should be dispensed with altogether and the applicant's standing determined solely from his experience sheet, supplemented by such oral examination as the special examiners deem necessary to fully ascertain the facts of the applicant's training and experience. While much may be said in favor of this suggestion, the committee foresees difficulties which would be likely to arise from the adoption of such a plan, and believes its introduction is not feasible, — at least until the Civil Service Commission has the proper organization thoroughly to investigate experience sheets; accordingly the committee recommends the continuation of the present practice of requiring applicants for examination in every engineering grade to pass written tests. No material change from the present practice is suggested, either in the subjects covered or in the character of the questions asked in the written examination, the committee feeling that this is a matter which the examiners have well in hand. Much less importance should be attached to the written examination in comparison with the experience rating than is the case at present, however, the specific recommendations on this point being given in the following paragraph. Further provision should be made so that the examiners shall

have the right, at their discretion, to subject applicants in any grade to oral examination, and this right should, it is believed, be generally exercised in the case of applicants for grades of junior and senior assistant engineer, as thereby the examiners will be better able to gage an applicant and give him his proper rating for experience.

6. *Weights to be Assigned in Examination.* The committee is strongly of the opinion that the relative weights assigned to written examinations at present are contrary to the best interests of the Service and such as to discourage able and experienced engineers from taking examinations for the higher grades in competition with younger and less experienced engineers, who, being more recently out of a technical school, are consequently less rusty in the theoretical subjects of the written examinations. The higher the grade the greater should be the rate allowed for experience and the less that allowed for written examination. The committee is of the opinion that a very considerable weight should be given for experience in the grades of junior and senior assistant engineer. On the other hand, it recognizes the limitations of the present organization of the Civil Service Commission for the investigation of Experience sheets, and accordingly, it recommends a set of weights for adoption at the examinations to be held in December, 1917, and another set of weights to be adopted after the Commission's staff has been strengthened adequately to investigate the experience of the applicants. In the following table, Group I shows the weights assigned at present; Group II, those recommended by this committee for the 1917 examinations, and Group III, those recommended for ultimate adoption.

In the case of applicants for admission to Grade A (rodman) who are graduates of a school of engineering of recognized reputation authorized by law to confer degrees, the committee recommends that graduation shall of itself count as a credit of 80 per cent. of the total experience mark, leaving 20 per cent. additional to be gained by the engineering graduates, who, in addition, have had actual field experience. As to the credit for experience to be given to graduates from such an engineering school, in the case of applicants for other grades, the committee recom-

Grade.		Group I. Weights Assigned at Present.		Group II. Weights Recommended for 1917 Examinations.		Group III. Weights Recommended for Ultimate Adoption.	
		Points.	Per Cent. of Total Rating.	Points.	Per Cent. of Total Rating.	Points.	Per Cent. of Total Rating.
A — Rodman or E — Junior Draftsman	Experience	5	31	2	20	2	20
	Written examination	11	69	8	80	8	80
B — Instrumentman F — Senior Draftsman	Experience	5	31	4	40	4	40
	Written examination	11	69	6	60	6	60
C — Junior Assistant Engineer	Experience	5	28	5	50	6	60
	Written examination	13	72	5	50	4	40
D — Senior Assistant Engineer	Experience	5	28	6	60	8	80
	Written examination	13	72	4	40	2	20

mends that this matter be left to the discretion of the Civil Service Examiners.

7. *Provisional Appointees.* In the case of provisional appointees, the committee is of the opinion that no provisional appointment should be made permanent, and no provisional appointee should be eligible for an increase in compensation, until such appointee has passed the examination for the grade to which he has been provisionally appointed.

8. *Retention of Names on Eligible List.* As a remedy for the unsatisfactory condition now existing by which names are automatically dropped from the eligible list at the end of two years, the committee recommends a modification of Rule 18 to provide that if, before the expiration of the original two years, the applicant so requests in writing, his name shall be retained on the list for an additional year; and, by written application made before the expiration of such additional year, further extension of a year may be granted; this to continue until the applicant's name has been retained on the list for a total period of at least five years.

9. *Certification of Names from Both State and Local Lists.* The eligible lists for all engineering grades in cities outside of Boston, and for the higher grades in Boston, being usually non-existent or containing an insufficient number of names to furnish the quota necessary to give the appointing officer the choice which is his right, the committee recommends that where the local list fails to supply the requisite number of names for certification, the lack be supplied by certification of names from the State list. This will probably do away, to a large extent, with the present practice of making provisional appointments in cities, especially those outside of Boston, in which there are no eligible lists or lists of insufficient names.

10. *Standardization of Work and Pay of Engineering Employees.* The committee is informed that an investigation is under way with a view to standardizing the work and pay of all state employees, including the civil engineering staffs of the state departments, and that the suggestion has been made, first, that the classification of engineer and draftsman should be wholly separate and distinct; and, second, that there should be

more classifications of engineers with pay graded in each classification. In regard to the first suggestion, the committee doubts the wisdom of separating draftsmen and engineers, and believes that they should both be included in the general classification of engineers.* The second suggestion regarding the classification of engineers and the grading of pay within the several classifications is evidently based upon the New York City Tentative Specifications for Professional Service, recently submitted by the Bureau of Standards to the Board of Estimate and Apportionment. In this connection the committee would point out that there is a fundamental difference between the Civil Service system of Massachusetts and that of New York and most other states. Elsewhere, state service and municipal service are wholly distinct so far as Civil Service regulation is concerned. New York City has its own set of Civil Service laws, rules and regulations, while an entirely different set applies to the Civil Service of New York State. In Massachusetts, however, all of the municipalities, as well as the several state departments, are comprised within the single Civil Service system. Having in mind rules and regulations which must be applicable alike to the municipalities and to the state departments, the committee is of the opinion that it would be unwise to increase the number of engineering grades beyond that recommended in this report; moreover, the committee doubts the wisdom of attempting to grade the rates of pay within each engineering grade for general application to all departments, as has been suggested in New York City. The grading of pay apparently requires legislative action, as evidenced by Chapter 605, Acts of 1914, establishing the grades for salaries of clerks and stenographers in departments of the Commonwealth. Further, it is believed that conditions applicable to New York City with many departments, each with a large engineering staff, would not apply to all of the state departments, or to all municipal departments, especially those in cities outside of Boston or even to some departments in

* The committee has since learned that, while, in general, it is proposed to separate draftsmen and engineers, consideration is being given to the proposal to include within the engineering classification those who may be termed "engineering draftsmen" in distinction from draftsmen who have not had special engineering training.

Boston itself. In many of these departments the number of engineering employees is so small and the conditions pertaining to their employment in the several departments and cities is so varied that, in the opinion of the committee, rigid grading of pay would not prove to be equitable alike to the engineering employees and to the state or the municipality which employs them.

Respectfully submitted,

(Signed) JOHN E. CARTY,
CHAS. R. GOW,
EDWIN H. ROGERS,
RUFUS M. WHITTET,
FREDERIC H. FAY, *Chairman.*

BOSTON, September 13, 1917.

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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

DISCUSSION OF "THE HISTORY AND PRESENT STATUS OF THE CONCRETE PILE INDUSTRY."*

By Thos. W. Clarke, Linton Hart, H. E. Sawtell, J. T. Scully, R. A. Hale and C. R. Gow.

Mr. Thos. W. Clarke.† — Mr. Gow's paper on the "History and Present Status of the Concrete Pile Industry" is certainly interesting and fills a void in engineering literature on this important branch of foundation construction.

In looking over Mr. Gow's paper, I notice several things about which you may be interested in hearing a little more, in addition to points treated by him which I will discuss. Assuming that that is so, I have gathered together a few photographs showing work which has been done, and some of the methods employed to overcome a few of the difficulties which have been encountered.

My experience in driving concrete piles covers a period of almost twelve years, principally with that type of pile which Mr. Gow refers to in his paper as the "Cast-in-place" pile. My observation of the work of driving concrete piles extends over a much longer time, I having seen some experiments carried out in Europe in the latter part of the 90's in which pre-cast concrete piles were being driven. I also saw some work which was done in Southampton in connection with one of the graving docks, at about the same time, I believe.

* Printed in the April, 1917, number of the Journal.
† Vice-President and Engineer, New England Foundation Co., Inc., 70 Kilby Street.

The first "cast-in-place" piles which I saw being driven were in New York; I think late in the summer of 1904. At that time the Raymond system was being used on West 23d Street, and the Simplex system was being used at the corner of Beaver Street and Broadway.

I was of the impression, until I read Mr. Gow's paper, that the piles which I saw driven in France were being placed during the late summer of 1894, but it is evident I am in error, and it was later than this, because Mr. Gow in his paper states that concrete piles were not driven in France until 1896.

The use of concrete piles in important engineering structures has now become recognized by engineers as sound professional practice.

I think it is only fair at this point in my discussion to pay tribute to the engineers and others who have been directly connected with this industry, and who have had the courage to spend an enormous amount of capital, energy and time, in the face of innumerable and seemingly insurmountable obstacles. To-day the leading engineers and architects all over the world have been brought to a fuller realization of the true value of the various devices and methods which have been developed and used successfully in securing a firm, positive and lasting method of constructing foundations for permanent engineering structures.

Referring to Mr. Gow's paper: He refers, on page 160, to the different types of cushions or pile-driving caps used to cushion the blow of the hammer. The practice of using caps to cushion the blow has reached a state of great perfection to-day, but many of the methods mentioned by Mr. Gow have proved unsatisfactory and undesirable for this purpose, and I think I might quote from my own experience the difficulties encountered and the devices we have finally found which give the most satisfactory service.

The New England Foundation Company, Inc., whom I represent as engineer, has found, when driving piles using the Simplex system, that a cast-steel driving cap seems to give the best results. This cap weighs about 500 lbs. and is cast in such a way that it permanently retains itself in the leads and offers a guide to steady the upper end of the driving tube or form.

This driving cap has cast on its upper face, a cup-shaped receptacle about 7 ins. deep and 12 ins. in diameter. Into this receptacle is fitted a hard-wood block which acts as a cushion

Courtesy of New England Foundation Co., Inc., Boston, Mass.

Fig. 1.

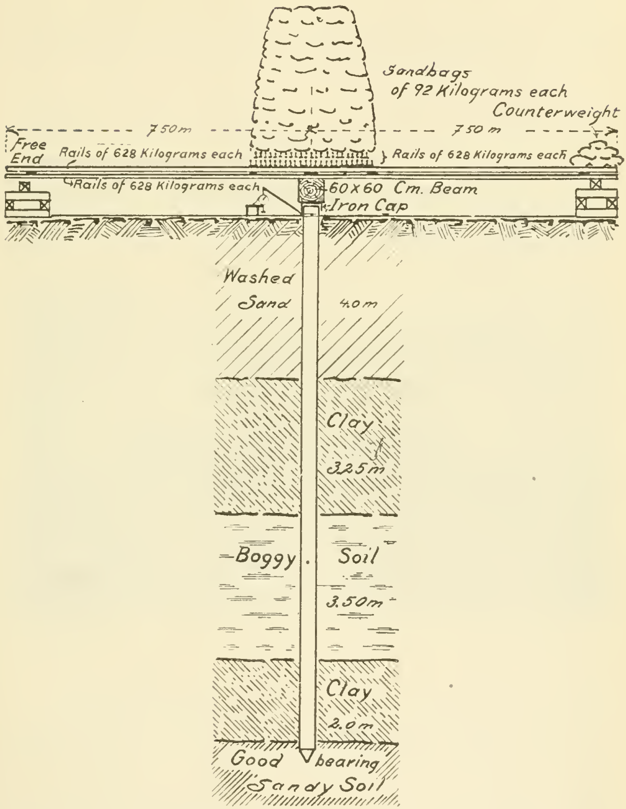
Standard Simplex Pile Driver, "Philadelphia Type." Gins 50 ft. from under side of head to bottom side of sole piece. Note that the driver is built without side braces, top being steadied with side guys controlled from the ground. This machine is built for drop hammer driving, with 40-ft. tube 16 ins. in diameter, and can drive piles over 60 ft. long, if necessary, using an extension tube.

between the hammer and the cast-steel drive block. We have tried many kinds of wood for a cushioning material, the work being so hard that only a tough and fibrous material can be

used successfully. The timbers best meeting these requirements, and which can be obtained in this country, are oak, gum wood or hickory. In China, where I drove 10-in. piles using methods similar to the Simplex system, I used an Eastern wood, found in the Philippine Islands and Formosa, called Yacal, a very tough and hard wood not obtainable, I believe, in this locality. I experimented with many materials before settling on this cushioning wood, among others sand being tried, and also sawdust. Both of these materials quickly became very much compacted under the repeated blows of the hammer, so that after a few piles were driven they became so hard that it was necessary to blast them out of the drivehead, as it was impossible to cut them out with stonecutter's tools. Our practice in driving has shown us that the work performed by driving caps is considerable, it not being uncommon, when the material penetrated is extremely hard, for the drive blocks to catch fire from the heat created by the impact of the hammer. The method of shaping these wooden blocks and the size used seems to vary greatly with different contractors. We use a block which has a top diameter of about 10 ins., a middle diameter of about 14 ins., and a bottom diameter of about 10 ins., the taper of the block on the lower portion being such that it fits snugly into the cup-shaped receptacle on the upper face of the cast-steel drive head. The blocks we use are considerably larger than those generally used in steam hammers, but we consider this necessary as the amount of work performed per blow of the hammer is considerably more than that of the larger size steam hammers used for similar work.

Some steam hammer manufacturers use a wooden block banded with steel hoops to confine the material and keep it from being shattered or broomed under the repeated blows from the hammer.

On page 161, Mr. Gow refers to the different types of hammers used, but unfortunately does not give us much information in regard to the desirability of different types. I think that much can be said by contractors or engineers in favor or against any type which they have used on their work, and I can only cite from my own experience in regard to this important device so



Courtesy of Kohncke & Co., Bremen, Germany.

FIG. 2.

Sketch in detail showing method of construction used in placing test loads on 16-in. Simplex Concrete Piles. Tests were carried out under the direction of the Hamburg Public Works Department, Hamburg, Germany.

necessary to the penetration of the pile in the ground. I personally have used both the steam hammer and the drop hammer, and have observed the following points in favor or against their use:

The steam hammer, as it is to-day, is a very rugged and reliable piece of mechanism, and is capable, I believe, of driving a greater number of piles or a greater penetration of piling in one day than the drop hammer, except in very elastic or rubbery material similar to peat or gumbo clay; but it has some serious disadvantages as follows:

For a given amount of work the weight of a steam hammer is about three times that of a drop hammer. It requires a larger boiler to operate it, more coal per day, and more cost for the maintenance of the pipe line and hose which conveys the steam from the boiler to the cylinder of the hammer. It also requires more water when the hammer is in operation, and more oil for lubrication. I consider that the weight of the hammer is a very great detriment to its use, particularly so when the hammer must be raised to the top of the gins when starting to drive a new pile. At this particular time, you have added four or five tons aloft, greatly endangering the stability of the driver. The additional weight of the hammer and engine increases the difficulties encountered when moving the driver from place to place on the site of the work, and also requires the payment of more freight in transporting the equipment from one job to another. It may also be noted that it will require as large an engine and the same number of drums to operate successfully as are required when driving concrete piles with a drop hammer.

I have observed, as above referred to, that the steam hammer in certain kinds of soil does not seem to give high speeds in penetration in driving operations. I have in mind two jobs which were executed in Greater Boston, one job which was being driven by a contractor using a No. 1 Vulcan steam hammer, I believe; the other job, which was driven by ourselves, using a 3 300-lb. drop hammer with a 10-ft. drop. The character of the ground which was being penetrated showed that there was a fill of from 6 to 8 ft. of ashes and miscellaneous material. This overlay a peat bed with an average thickness, I believe,

of 8 ft. The peat overlay a clay bed of varying thickness and consistency. Inasmuch as the two jobs were only about 800 ft. apart, and the material was practically of the same consistency, and as the borings on the two jobs showed similar conditions as regards thickness of the different strata, etc., it is reasonable to suppose that the work performed by the hammers

Courtesy of Public Works Department, Hamburg, Germany, and Kohncke & Co., Bremen, Germany.

FIG. 3.

Usual method of testing Simplex Concrete Piles by Public Works Department, Hamburg, Germany.

Test load, 94 tons, on one 16-in. diameter pile. Note how the load is trimmed by the use of a few sand bags placed on the outer end of the two upper tiers of rails.

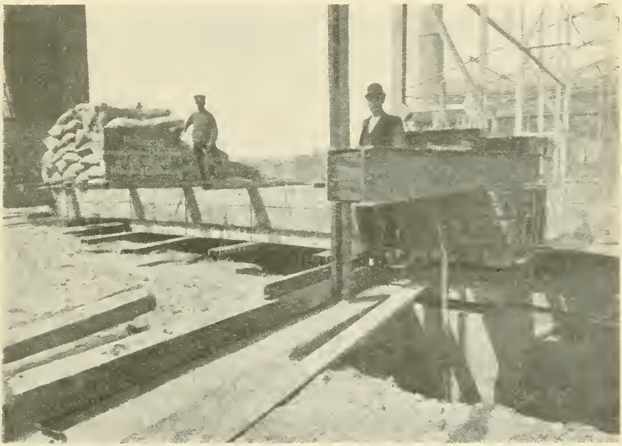
on the two jobs was similar. On the job where the steam hammer was used, 240 to 280 blows of the hammer were required for the driving form to penetrate the peat, the speed in this case being about 60 to 65 blows per minute. The striking weight, I believe, was 5 000 lbs. and the drop 42 in. On our job, using a drop hammer, we penetrated the peat in from 12 to 16 blows at a speed of 30 blows per minute with a striking weight of 3 300 lbs.

and a drop or free fall of 10 ft. It seemed to me at that time as if the steam hammer did not have kinetic energy enough to overcome the elasticity of the material which was being penetrated.

We also feel that the carrying capacity of the pile when driven by a steam hammer cannot be determined so reliably when using any of the many formulæ which purport to give the carrying capacity of the pile, in which the factors used are the penetration of the pile in a given number of blows, in conjunction with the weight of the hammer and its drop. Our reluctance to use the steam hammer and these formulæ can be understood when you consider the results as regards penetration in driving through elastic materials as observed above. It has been observed by other engineers who have used both the steam and drop hammer that the *Engineering News* formula for the drop hammer gives a safe carrying capacity for the pile, whereas its formula for steam hammers in some cases gives a dangerous carrying capacity. This can be best shown by referring to the *Engineering News*, Vol. 75, No. 1, January 6, 1916, page 33, in which a reference is made to comparative tests carried on at the Naval Dry Dock at Pearl Harbor, Island of Oahu, Hawaiian Islands, and also at the Naval Dry Dock, Mare Island Navy Yard, California, the article being entitled "Tests Comparing Steam and Drop Hammer Formulæ." I will not take space in this discussion to set forth this article, but only say briefly that Civil Engineer E. R. Gayler, U.S.N., considers, after testing piles from 80 ft. to 100 ft. long, driven with a penetration of from 40 ft. to 50 ft. without the use of follower (he having tested at Pearl Harbor nine piles driven with the drop hammer and eleven piles driven with the steam hammer in similar soil), that the steam hammer formula referred to above gives a dangerous value for carrying capacity of the pile.

The advantages in the use of a drop hammer we consider to be as follows: For a given amount of work the hammer is considerably lighter; for instance, a steam hammer of the Vulcan type would weigh about 10 000 lbs., whereas the hammer which we use and which is considered about equal in capacity to the hammer above cited would weigh 3 300 lbs. You do not have so much weight aloft nor so much mechanism to keep in repair

and to maintain; there is no steam hose used, with its liability to delay operations by bursting or blowing off, nor pipe lines with the consequent radiation. You also have a device which is elastic, inasmuch as you can increase or decrease the intensity of the blow by increasing or decreasing the drop of the hammer. This is particularly desirable at times where it is advantageous to penetrate certain materials with either greater or less speed,



Courtesy of Hamburg Public Works Department, Hamburg, Germany, and Kohncke & Co., Bremen, Germany.

FIG. 4.

Testing Simplex Concrete Piles at Hamburg, Germany, using the cantilever method; load on pile, 88 tons. This work done under the supervision of the Hamburg Public Works Department. Note the small amount of material used to secure the desired load; also the length of the lever arm, about 30 ft. 0 ins.

as the occasion demands. The weight of the equipment, as pointed out above, is less, making it easier to move the driver over the ground and costing less when transporting the equipment from one job to another. On the other hand, I am willing to concede that a job cannot be driven with as great a speed in many cases as when using the steam hammer, but the advantages

gained in the reliability of the piles and their ability to carry the load more than offset the undesirable features cited above. I might also point out that the wear and tear of hammer ropes is considerable, involving additional expense in maintenance, more so, I believe, than in the maintenance of steam hose for the steam hammer.

On page 164, Mr. Gow refers to the straight-sided versus the tapered pile as regards the carrying capacity. There is one point that he has not mentioned in regard to the merits of straight-sided piles which is well known to engineers who have followed closely the different evolutions in connection with the development of the cast-in-place pile. The cast-in-place pile which is now on the market, and which uses a form with an extreme taper, does so primarily because they have found it impossible to build a device which they could collapse and withdraw from the ground easily, unless they used the tapered design, and as their mechanical construction requires this type of pile, they have taken advantage of this fact and made what they consider a strong talking point for their pile. I think the disadvantage of this type of pile can be best illustrated by citing a case which came under my observation wherein test piles were driven through about 11 ft. of loose fill into hard glacial drift which probably carried the entire load superimposed on the pile. In one case a taper pile was driven which had a penetration of about 17 ft. 6 ins., of which about 6 ft. 5 ins. was in the hard material. This pile where it entered the hard material had an area of about 90 sq. ins., which with a working load of 60 000 lbs. gave a stress on the concrete of about 667 lbs. per square inch; with the usual test load of 120 000 lbs., the stress on the concrete was about 1 333 lbs. per square inch, and in the case of the maximum test load which was applied to this pile, of 175 870 lbs., the stress was 1 954 lbs. per square inch. It is interesting to note that this pile commenced to show settlement ("$\frac{1}{8}$ of an inch") at 60 000 lbs. This continued progressively with every increment added until at the maximum test load the settlement was "$\frac{19}{32}$ of an inch." The surface area of the pile in the hard material, including the hemispherical point, was approximately 15.6 sq. ft. Referring to the stresses indicated above in the concrete,

it is interesting to note that the stresses under working conditions in the pile where it entered the gravel were about 50 per cent. higher than are recommended by the American Society of Civil Engineers in their joint Report on Concrete, or allowed by the building authorities.

The other pile was of the standard Simplex type, straight sided and 16 ins. in diameter for its full length, and was driven

Courtesy of Cranford Construction Company, Pittsburg, Pa.

Fig. 5.

Method of loading 300 tons on five 16-in. Simplex Concrete Piles, tested at Westinghouse Machine Company, Pittsburg, Pa.

within a few feet of the above test, at about the same time, having a penetration in the ground of 14 ft. 6 ins. This pile was driven into similar material of practically the same thickness, and had a penetration in the gravel of only 4 ft. The diameter of the pile where it entered the gravel was about 16 ins., giving a cross-sectional area of 201 sq. ins., which with a working load of 60 000 lbs. gave a stress on the concrete at this point of about

Courtesy of New England Foundation Co., Inc.

FIG. 6.

Method of loading 96.13 tons on one Simplex Concrete Pile tested at the Massachusetts Institute of Technology.

Testing plate, cast iron, 2 ins. by 24 ins. by 24 ins.

Two 15-in. 42-lb. I-beams 10 ft. 0 ins. long.

Eight 6-in. by 14-in. yellow pine beams, 10 ft. 0 ins. long.

Deck, eight 6-in. by 14-in. yellow pine, 10 ft. 0 ins. long.

Leveling rod, 1-in. pipe 15 ft. 0 in. long, grouted into pile, and extending up through deck and pig iron above top of load.

Load is balanced on the head of pile, which is well braced. Notice the 12-in. by 12-in. yellow pine timbers under the four corners of the load. Wedges are used between the top of these timbers and the yellow pine 6-in. by 14-in. beams which support the deck.

These wedges are used when loading the pile, the platform being wedged up after leveling, the test load being shifted until the pressure on the wedges is equal and the wedges can easily be removed by hand.

297 lbs. per square inch; with the usual test load of 120 000 lbs. this stress was about 595 lbs. per square inch, and with the load carried by the other pile of 175 870 lbs., the stress was about 875 lbs. per square inch. This pile carried a maximum load of 192 270 lbs., which gave a stress at this point of about 955 lbs. per square inch. It is interesting in this pile to note that it commenced to show a settlement ("$\frac{1}{8}$ of an inch") at 61 280 lbs; this settlement was observed to be "$\frac{3}{16}$ of an inch" at 85 800 lbs. and was not observed to increase until a load of 153 810 lbs. was on the pile, the observed settlement at this point being only $\frac{1}{4}$ in. The observed settlement, at the nearest increment to the maximum load on the taper pile at which readings were taken, was $\frac{9}{32}$ of an inch, being $\frac{5}{16}$ less than the other pile The observed readings at the maximum load was $\frac{7}{16}$ of an inch, being $\frac{5}{64}$ of an inch less than the other pile. The surface area of this pile in the hard material, including the conical point, was about 15.8 sq. ft., only $\frac{2}{10}$ of a square foot more than the other pile. The argument for the advantage of a straight-sided pile over a tapered pile under similar conditions seems to be proven in this case and is as follows: Lower stress in the concrete at the point where the load must be carried, larger compression of the soil, larger surface area of the pile, necessarily increasing its friction and carrying capacity, and, most important from the engineer's and owner's standpoint, a shorter pile is required for an equal load capacity, this of course involving less expense to the owner.

On page 177, Mr. Gow refers to the Simplex type of pile. I think perhaps you may be interested in knowing a little of the origin and history of this type of construction, particularly as it occurred in the early stages of the concrete pile industry.

In the fall of 1902, the U. S. Government was called upon to erect a group of buildings for the Engineer school at Washington Barracks, Washington, D. C. The site selected was very low swampy land, in which the overlying material was evidently of such a character that it was not considered possible to construct these buildings without serious settlement unless widely spread footings were used. The cost of going down to good bearing soil or the use of wooden piles cut off at the permanent water level was prohibitive and out of proportion to the cost of the

superstructure. Capt. J. S. Sewell, Corps of Engineers, U. S. Army, who was directly responsible for this work, discussed one day his troubles with Mr. Cranford, a personal friend and a leading engineer in Washington, D. C., who in turn happened to mention the difficulties to Mr. Frank Shuman, a well-known designing engineer who happened to be in Washington at the time. When these difficulties were mentioned to Mr. Shuman, he replied immediately, "Why, that is easy; just punch holes

Courtesy of Galena Signal Oil Company, Bayway, N. J., and New York City.

FIG. 7.

Simplex Concrete Piles extended up as reinforced concrete columns without the use of pile caps or footings.

Such jobs are possible only with concrete piles, as the uniform straightness and rigidity of the pile-forming apparatus allows great accuracy in driving the pile in the desired location.

Single piles were extended in this way to support a tank platform; maximum load on piles, tanks filled with water, about 45 tons. Piles driven to rock through the soft strata overlaying red New Jersey shale rock.

Piles driven for the S. T. Baker Oil Company at Bayway, N. J., by the Foundation Company, New York City.

in the ground and fill them with concrete." Mr. Shuman's remarks were received at that time as a jest. He, however, was not joking, and proceeded to make some experiments, and shortly afterwards placed a hastily rigged pile driver at the Washington

Barracks for experimental purposes. The first experiments used a 10-in. extra heavy pipe, driving a tube with a conical point into the ground, the tube then being withdrawn and concrete being shoveled into the hole. This was found to be unsatisfactory and later changed by leaving the pipe in the ground and withdrawing it after the concrete had been poured. The

Courtesy of New England Foundation Co., Inc., Boston, Mass.

FIG. 8.

Exposure test on one 16-in. Simplex Concrete Pile driven in a group of one hundred twenty-one piles for a stack foundation at the Pacific Mills, Lawrence, Mass. See Fig 14.

Note the rough surface of the pile, giving larger skin friction than with a smoother surface pile; also the action of the pile on the different strata of the earth, showing that the compression of the earth does not extend but a short distance from the outside surface of the pile.

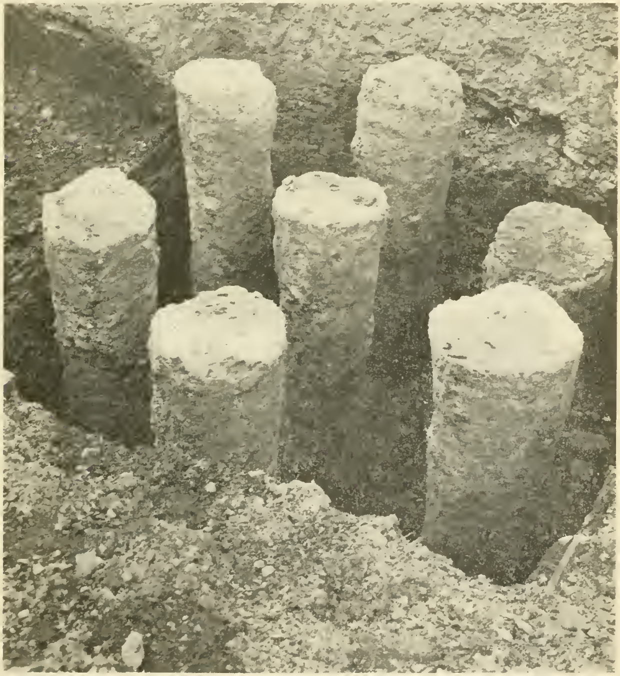
buildings at the Navy Yard were constructed on piles driven in this way and are to-day standing intact without crack or settlement. The methods employed then were improved upon from time to time until those used to-day were evolved, so that now, as the result of a seeming jest, thousands of buildings and important engineering structures are standing all over the world built at a lower cost than would be possible under the old method of deep foundation or spread footing.

Continuing the discussion of the Simplex pile, Mr. Gow unfortunately mentioned in the text, and illustrated with cuts, two jobs showing distortion of cast-in-place piles. Fig. 29 on page 180 shows experiments carried out by Francis L. Pruyn, a well-known engineer in New York, who was endeavoring to find the faults or advantages of certain types of cast-in-place piles. This test was not driven using the Simplex system, nor were any men employed on this work who were familiar with the technique or methods used in driving the Simplex pile at that time.

Referring to the cut shown in Fig. 30, page 181, I will say that this work was on Fourth Street, New York. It was driven about 1912, by a contractor who used methods and apparatus entirely different from the Simplex system. I do not know whether or not the conditions shown in the cuts actually existed, as we were not at all interested in the matter, but I think it only fair to say that the methods which I understand were used at that time have been changed and that this type of pile has been considerably perfected.

Mr. Gow also mentions, on page 182, and illustrates in Fig. 31, conditions on a job in Chicago which was driven under the Simplex system, but under conditions in which the length of the piles driven was not under the control of the Cranford Construction Company, who were doing the work. This job was the Borland Building in Chicago, and was written up and the figure shown drawn by a man who was not familiar with the conditions at the site and was not in any way directly connected with the construction involved. This job resulted in a damage suit in which experts were called in, the ultimate outcome being that this method of construction was vindicated,

and a decision was granted in favor of the contractors on this work. The evidence in this case, which included the testimony of "sand hogs" employed on this work, proved that the concrete piles were perfect throughout their entire length. Copies of the papers in connection with this job are at the office of the New England Foundation Company, Inc., and we shall be very glad to



Courtesy of New England Foundation Co., Inc., Boston, Mass.

FIG. 9.

Exposure test Simplex Concrete Piles at the Young Men's Christian Association Building, Hartford, Conn. Piles driven 3 ft. 0 ins. centers, loading 30 tons per pile.

show them to any one who is interested in knowing what the conditions actually were. I have taken the liberty of citing this last case, as I think it only fair to the Simplex system to set forth the facts in detail, as the natural inference would be

Courtesy of Cranford Construction Co., Pittsburg, Pa.

Fig. 10.

Exposure test on group of 16-in. Standard Simplex Concrete Piles driven for the foundation for the George A. Kelly Co., Pittsburg, Pa.

Note the rough surface of the pile, giving high frictional value; also the size of the pile compared to the man in the foreground.

for one to assume that these jobs were all Simplex jobs, a condition that I am sure Mr. Gow did not intend to imply when he wrote this article.

In the Simplex concrete pile the cast-iron point is slightly larger than the tube, which is 16 ins. in diameter, while the cast-iron point is $16\frac{3}{4}$ ins. in diameter. The point is made in this manner so as to be sure that it will detach itself from the tube when the latter is withdrawn from the ground. Before

Courtesy of Cranford Paving Co., Washington, D. C.

FIG. 11.

Exposure test on four 16-in. Standard Simplex Concrete Piles driven for the foundation of the Baltimore Bargain Warehouse Co., Baltimore, Md.
These piles 30 ft. 0 ins. long were exposed for 25 ft. 0 ins. of their length.

driving, the point is calked watertight on the tube with rope yarn and grease. The effectiveness of this calking has been demonstrated many times by leaving the pile form unfilled after

driving in the ground over night and finding the bottom dry in the morning even in water-bearing soil.

In driving the Simplex concrete pile, the different operations are as follows: The pile stake is removed from its location, the cast-iron point is set in the hole left by the pile stake, the pile driver is brought into position with the 16-in. driving form hung in the gins directly over the point, the driving form is

Courtesy of F. L. Cranford, Inc., New York City.

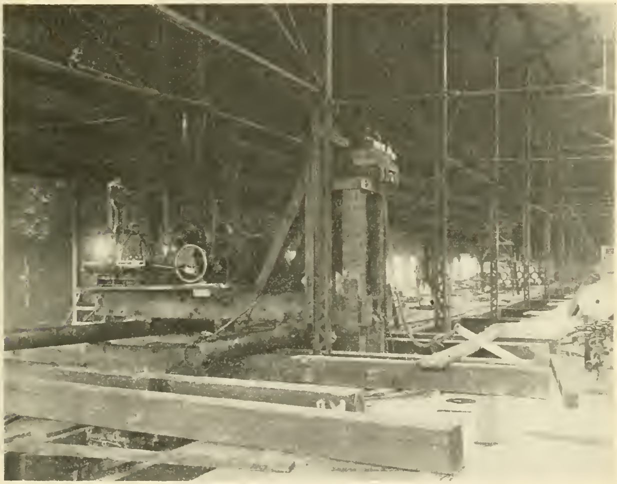
FIG. 12.

Sheet Steel Pipe Piles driven for underpinning under Trinity Church vestry, Church Street, New York City.

This work was undertaken by F. L. Cranford, Inc., engineers and general contractors for one section of the Tri-Borough Subway, and was carried out under the direct supervision and approval of the Public Service Commission, State of New York, Second District.

lowered over the neck formed at the top of the cast-iron point, and driving operations are started with the drop hammer in the usual way. After the driving form has been driven to the desired penetration and the hammer and drive head have been

secured aloft, the form is filled part way with concrete and a strain is taken on the pulling apparatus. As soon as the form has been pulled six or eight inches, it is filled with wet concrete to a height of several feet above the surface of the ground. Inasmuch as the cross-sectional area of the tube wall is about



Courtesy of Cranford Construction Co., Cincinnati, Ohio.

FIG. 13.

Reconstruction of the foundations under the Panhandle Freight & Warehouse Co., Cincinnati, Ohio.

The foundation under this building failed, threatening destruction of the structures, during one of the numerous floods in the Ohio River.

This building was conserved and the foundation reconstructed, using 16-in. Standard Simplex Concrete Piles 68 ft. 0 ins. long, driven in an available headroom of only 14 ft. 0 ins., using the extension tube method, the work interfering but little with the occupation of the building as a freight station and warehouse.

18 per cent. of the total cross-sectional area of the finished pile, it is always necessary when filling piles, which are to be finished at the surface of the ground, to fill them as above described. As the pile form is pulled, the wet concrete in the form feeds

down, flowing out around the end of the form, cementing itself against the earth, thus filling the hole. The form when withdrawn leaves a perfect shaft of concrete 16 ins. in diameter resting on a cast-iron point.

The carrying capacity of the pile is usually arrived at by

Courtesy of New England Foundation Co., Inc., Boston, Mass.

FIG. 14.

Stack foundation at the Pacific Mills, Lawrence, Mass.

One hundred twenty-one 16-in. Simplex Concrete Piles driven 3 ft. 0 ins. centers both ways.

Note the perfect alignment of the piles always noticeable on cast-in-place pile jobs, due to the uniform shape of the cast-iron pile points and shape of the pile-forming apparatus.

using one of the many formulæ which have for factors the weight of the drop hammer in conjunction with its drop and the penetration of the form. Inasmuch as most of these formulæ now used were intended primarily for use with wooden piles, it is evident that the results obtained, when applying these formulæ in the use of rigid steel driving forms, would show a lower carry-

ing capacity than that which the pile really has, because, in driving the wooden pile, it may be observed that excessive vibration occurs (sometimes shattering the pile) which naturally prevents a large part of the energy developed by the hammer from reaching the point of the pile, whereas when using our pile-forming apparatus, which is very rigid, it is evident that a very much larger proportion of the energy of the hammer reaches the point of the pile.

Mr. Gow, in his paper, on page 183, refers to the rate of progress in driving Simplex piles. We know from experience, taking into consideration many jobs, that we average driving our piles in as good or better time than other contractors who drive the cast-in-place pile, and we or the others, and I say this unreservedly, can drive a given job with greater speed than is possible with the pre-cast type of pile.

Mr. Gow also refers to the severe strains brought upon the pile drivers because the tubes must be withdrawn from the ground after being filled with concrete, stating that it is not uncommon to lose a large amount of time on account of repairs to the equipment. Mr. Gow is in error, I believe, about this. In the first place, all cast-in-place pile-driving equipment is required to have enormous power to withdraw the tubes. We know that our machines, through many years of experience, are built more rugged, the mechanism is simpler, and I believe less time is lost on account of repairs to equipment, than in any other type of machine used in driving cast-in-place piles or concrete piles of any type.

On page 186, Mr. Gow compares the Peerless pile with the Simplex and Pedestal type, stating that it is not possible to drive Simplex or Pedestal piles over 50 ft. I cannot state as to the length it is possible to drive the Pedestal pile, but in the case of the Simplex, many jobs have been driven with a 50-ft. machine, using the extension tubes, in which the length of the finished pile was as high as 60 ft. In Germany, Kohncke & Co., licensees for the Simplex system, have driven many jobs over 50 ft., and one job in which the piles averaged 75 ft. 5½ ins., the average penetration being 85 ft. 4 ins. The driver used for this work was about 95 ft. high. We ourselves have driven many

jobs in which the piles were from 55 to over 60 ft. in length, and one job at Portland, Me., the longest pile was 67 ft., using a tube 76 ft. long and a driver which was about 85 ft. high.

On page 187, Mr. Gow refers to tubular piles which have

Courtesy of Kohncke & Co., Bremen, Germany.

FIG. 15.

Driving 16-in. Simplex Concrete Piles at Schwerin, Mecklenburg, Germany.

Penetration of driving form, 85 ft. 4 ins. Length of finished pile, 75 ft. $5\frac{1}{2}$ ins.

been driven extensively in New York City. This type of pile is very expensive, due to the cost of the steel tubes or pipes, which are of necessity left in the ground, but on account of the

geological conditions in New York, particularly on Manhattan Island, where these piles are mostly driven, very high loads can be carried, thus materially reducing the cost of the piles when considered on the per ton carrying capacity. The tubular pile is made up in several ways. One method is to use $\frac{5}{16}$-in. or

Courtesy of Portland Gas Light Co., Portland, Me.

FIG. 16.

Special Simplex Pile Driver. Gins, 80 ft. 0 ins. long from the under side of the head to the bottom side of sole piece. This pile driver was built using a 50 ft. 0 in. Standard Simplex machine, with a special detachable 30 ft. 0 in. section below. On account of the height of the machine, side braces were used as well as side guys. This machine used a 76 ft. 0 in. tube 16 ins. diameter, and drove piles 67 ft. 0 ins. long.

$\frac{3}{8}$-in. steel pipe in suitable lengths for handling, sometimes as short as 2 ft. for underpinning work, and where possible the full "random" length of 20 ft. or over. Another method is to drive a thin sheet-steel tube or pipe which is built up out of steel plates rolled up and shaped into a cylinder and riveted

Courtesy of New England Foundation Co., Boston, Mass.

FIG. 17.

Driving 14-in. Steel Pipe Piles without the use of a pile driver. Steel gins handled by derrick, desired batter obtained, and gins guyed securely in position. Drop hammer used operated by pile fall over derrick boom; engine at some convenient point. Cast-iron points were used, thus compacting the soil, increasing the carrying capacity and also saving excavating the pile.

Piles driven for the Metropolitan Park Commission at the Charles River Bridge, Norumbega Park, Auburndale, Mass., under the direction of John R. Rablin, engineer for the commission.

together. These are usually made in two-foot lengths with a thickness of metal of only $\frac{7}{64}$ of an inch.

Several ingenious methods have been devised for driving, excavating and filling these piles with concrete. In the case of the steel pipe piles above referred to, it is not usually a custom to erect a pile driver on the site, but where long lengths are driven, a four-legged timber frame is set up on the ground which has suitable cross bracing so arranged that it acts as guides to steady the pipe and keep it in a vertical condition while driving. A special hammer is used in which the power is furnished by compressed air instead of steam. This hammer has a specially designed base, which fits snugly over the top of the pipe. The pipe in this case has no point, the ends of the pipe forming a cutting edge. The pipe is driven into the ground to the desired depth, sometimes several lengths of pipe being put one on top of another, being coupled together with inside couplings or sleeves of cast-steel, having at their center a rib or outside projecting ring, the top and bottom faces of which are beveled towards the sleeve. The outside diameter of this rib is practically the same as the outside diameter of the pipe. The outside diameter of the sleeve or coupling is slightly larger than the inside diameter of the pipe. The purpose of this construction is to make this sleeve snug and watertight and yet crowd the ends of the pipe against the sleeve to prevent any tendency to split or telescope the pipe. This is done by the bevel of the rib on the top and bottom faces. Many other devices have been tried, but have been abandoned in favor of the sleeve described above. The sleeve shown on page 188 and described by Mr. Gow has been abandoned for some time.

After this pipe has been driven to the desired penetration, usually a slight distance into the rock formation, it is excavated, using a very ingenious pneumatic method. A large size pneumatic compressor is installed on the work, having one or more good-sized air flasks which are used to store air at about 90 lbs. pressure and give a tremendous volume instantly for the work to be done. This air is led from the flasks to the driven pipes through steel tubes of 3 or 4 ins. in diameter, and from the end of this tube through a flexible hose and a piece of 2-in. pipe long

enough to reach to the bottom of the driven pipe. This is lowered into the interior of the driven pipe. The driven pipe is then filled to the top with water and a steel bit is churned up and down to loosen material inside of it as much as possible, and to allow the 2-in. air pipe to sink as far down as necessary into the interior of the driven pipe. Air is then turned on in the 2-in. air pipe, using a quick opening valve, giving the full volume of the opening immediately. A tremendous amount of air rushes through the pipe and discharges downward from the end of the 2-in. air pipe, loosening the material inside of the driven pipe. This tremendous volume of air lifts the material out, sometimes throwing it 15 or 20 ft. in the air. Bowlders are ejected from the driven pipe by this method which are sometimes over half its diameter. The speed with which this excavating can be done is remarkable. If ample air capacity is available, pipes 60 ft. long have been cleaned out in fifteen or twenty minutes bone dry, and the surface of the rock at the bottom has been removed where the rock is at all soft, ready for immediate concreting operations. If the steel tube projects above the desired elevation of the cut-off, the top is removed by cutting through the steel with an oxy-acetylene flame. The tube is then filled with concrete. All the equipment used on the work is handled with a stiff leg derrick or other suitable device.

The New York Building Department has written in their building laws, special provisions for this type of pile, having provided under Article 12, Paragraph 235, Subdivision 3A, in the New Building Code, specifications for concrete-filled steel tubes, which in substance state that the diameter shall be 9 ins. or more, the thickness of the steel walls not less than $\frac{5}{16}$ of an inch, the ends of the tubes faced perpendicular to the axis, and the splices of approved design. The length of any such pile, it is stated, shall not exceed forty times the inside diameter of the tube. The most interesting provision in this specification is that which takes into consideration the value of the steel tube as a supporting medium. This clause is as follows: "The allowable load shall not exceed 500 lbs. per square inch on the concrete and 7 500 lbs. per square inch on the steel, provided that in computing the effective area of the steel the outer $\frac{1}{16}$ of

an inch of thickness shall be deducted from the thickness of the tube. No interior steel reinforcements shall be used." The deduction noted above of $\frac{1}{16}$ of an inch in the thickness of the tube was made after observation covering many years, of the corrosive action on the exterior surface of these pipe piles, and it has been determined that this corrosive action does not extend $\frac{1}{16}$ of an inch in from the outside surface.

The other type of steel pile described above is driven in an entirely different manner. These built-up steel tubes are

From "Modern Underpinning," by Lazarus White, C.E., and Edmund Astley Prentis, Jr., E.M.

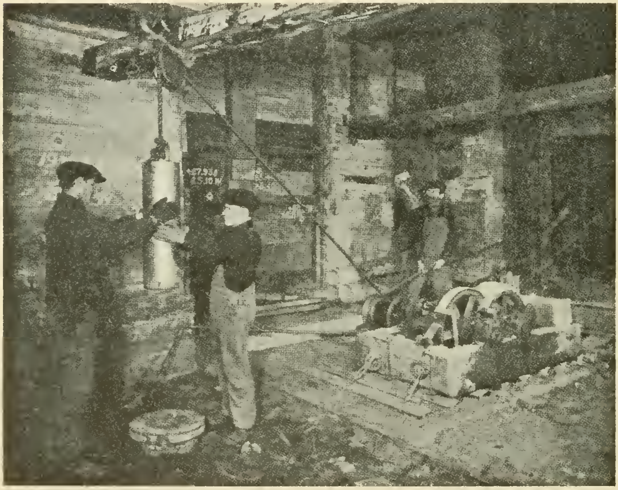
FIG. 18.

Two sizes of approved sheet-steel pipe pile sections are shown, 12 and 14 in. diameters. Section on the extreme left is a so-called starter section. The two other types shown are so-called follower sections.

Over 100 000 ft. of this type of sheet-steel pile has been driven under the new Tri-Borough Subway, New York City, with the approval of the Public Service Commission, State of New York, Second District.

usually made in two-foot lengths with a thin steel reinforcing band riveted on the outside at the top and a thin steel reinforcing band or sleeve riveted on the inside at the bottom, which projects 2 or 3 ins. below the bottom of the pipe. These pipes are set one on top of the other and driven into the ground without

a point, the bottom end of the pipe forming the cutting edge. The method employed in driving is to put a cast-steel cap weighing about 250 lbs. over the top end of the pipe. On this is dropped a weight or hammer usually 9 ins. in diameter and weighing from 400 to 500 lbs. A very small amount of apparatus is used in driving. This consists of a snatch block, which



Courtesy of Public Service Commission, State of New York, Second District, and F. L. Cranford, Inc., New York City.

FIG. 19.

Driving 14-in. sheet-steel pipe piles to be filled with concrete after being excavated and cleaned out.

Note the drop hammer, weighing about 500 lbs., dropping three feet and guided by two men while striking the blow; also the electric winch in the background with the winch man operating the pile hammer fall over the winch head.

These piles were driven in the new Tri-Borough Subway, New York City, by F. L. Cranford, Inc.

is fastened at some convenient point directly over the pile, through which is led a manila hammer fall, one end of which is secured to the hammer, the other end passing around the nigger-

head on a small electric winch. This winch is run at a steady speed, the hammer being raised or lowered by the winchman tightening or loosening the several turns of the hammer fall around the winch head. The hammer is guided in its drop of 2 ft. or 3 ft. by one or two men grasping the sides. It is not usual to drive any great depth at one time with this apparatus without excavating the interior of the pile. This is generally

Courtesy of Public Service Commission, State of New York, Second District.

FIG. 20.

Driving 14-in. sheet-steel pipe piles in new Tri-Borough Subway, New York City.

Note the electric winch used to hoist the hammer, in the foreground, with the man guiding the hammer driving the pile directly in the rear.

Finished piles can be seen supporting the roof, also under the large pier in the center of the picture.

done by using one of two methods. If the material being penetrated is not very compact, a large jointed auger fitting loosely inside of the pipe is used, but this is not practical when the digging is any considerable depth below the men operating the

auger. If the material is compact or the digging is some distance below the top of the pile, a small orange-peel bucket is used. These buckets are small enough to open their full size inside of the pile, some buckets being made to open inside of a circle 10 ins. in diameter, others being made for 12-in. and 14-in. diameter circles. These buckets differ only from the larger size buckets with which we are all familiar in that they are fitted with a small ball weight which can be used as a hammer to drive the blades into the material to be excavated and also give additional weight to the bucket when it is being closed. These buckets can be operated over small pulleys by hand without the use of winch or other mechanical devices for pulling the lines, when closing and raising the bucket.

Several hundred thousand feet of piling have been driven under the new subways in lower New York within the last four years, using this method and this type of pipe pile.

Still another method is employed in driving steel-pipe piles, — the hydraulic system. This has been very clearly described by Mr. Gow, and I do not think it necessary to amplify this, except to say that at times very large rams and very high pressures are used. This is particularly so when it becomes necessary to drive the pipe with the lower end closed with a point. Of course the use of the point compacts the earth and considerably increases the resistance in driving. This last-mentioned process of driving is only used, I believe, where it is practically impossible to clean out the inside of the pipe for concreting. Difficult underpinning along the subway and under some of the high buildings in New York has been undertaken using this last method.

On page 189, Mr. Gow refers to the Compressol pile. This method was originated and perfected, I believe, by Mr. Hennebique, one of the pioneers in reinforced concrete construction in Europe, and I am glad to testify to the fact that he was also a pioneer in the concrete pile industry. Pre-cast piles were driven in France in the late 90's from designs prepared by him and under his direct supervision. The Compressol job referred to by Mr. Gow in his paper as having been driven at Perth Amboy, N. J., was work which was executed for the

Cheseborough Manufacturing Company. I am more or less familiar with this job, as the plans were submitted to me for my opinion when I was acting as consulting engineer for the Cheseborough Manufacturing Company. The character of the soil was such at this job, and the loads were so heavy and concentrated, that it was thought this type of pile would give excellent results. Although the methods used seemed very crude com-

Courtesy of Public Service Commission, State of New York, Second District.

FIG. 21.

Driving 12-in. steel-pipe piles with hydraulic jacks. Underpinning one of the skyscrapers along the route of the new Tri-Borough Subway, New York City.

Note the hydraulic jack with the flexible copper pipe leading to the hydraulic pressure pump.

pared to methods employed by other concrete pile drivers, the results obtained were highly satisfactory and the buildings which were constructed on these piles were at last reports in excellent condition, without crack or settlement. I never have understood why more piles have not been driven in this country by use of this method, as it has evident merit.

There is another method employed in making concrete piles which originated in Belgium. This is the so-called Frankignoul pile which is driven using a series of tubes fitting one inside of the other, like a telescope. The lower ends of these tubes are closed with a point which can be controlled from the surface of the ground. This point engages an inside collar on the lower tube in such a manner that when the point is driven into the ground it drags the tube down with it. The tube on its upper end has an outside collar or projection which in turn engages an inside collar on the next length pipe in which the lower pipe telescopes. This method of constructing the tubes can be increased to an indefinite length, and piles, I believe, have been driven in Belgium to a considerable depth. The peculiar part about this method of driving piles is that the striking weight or hammer is so arranged that it strikes directly on the point, it being operated entirely inside the tube on a rod leading from the point. The piles formed by this method are very large in diameter, at times, I believe, as much as a meter across. I understand no piles have been driven by means of this method in the United States, although I think it was under consideration at one time by some engineering contractor in the Middle West. From photographs and data which I have in my office, I learn that one pile was driven at Liege, Belgium, with the mean diameter of 40 ins. The pile tapered from 50 ins. to 28 ins., the small diameter being at the bottom. It was loaded with 530 metric tons, equal to about 584 short tons. The total settlement was $1\frac{37}{64}$ ins.

Another method not mentioned by Mr. Gow is the Siegwart, a Swiss pile owned by the Siegwart Pile Company, of Lucerne, Switzerland. This pile is made by driving a tube about 16 ins. in diameter into the ground. After the desired penetration is reached, the tube is withdrawn about 5 ft. and a charge

of dynamite is exploded in the ground, making a cavity at this point. This cavity and the tube are filled with concrete, thus forming a concrete pile with an enlarged base. These two last methods are described in the February, 1914, issue of the *Railway Engineer*, published in London, England.

Under the head of "Combination Piles," on page 194, Mr. Gow refers to the Ripley pile. This is a wood pile pri-

Courtesy of New England Foundation Co., Inc., Boston, Mass.

FIG. 22.

Standard Simplex Pile Driver, "Philadelphia Type." One of the operations in driving Simplex concrete piles — "setting the driving form on the cast-iron point." Note size of points in foreground. The form is fitted over the point without shifting its position. Note rugged construction of driver gins.

marily for water work, which is covered with a protective coating of concrete, the purpose of which is to protect the pile from the attacks of the teredo and limnora. This concrete protection is now held in place, I believe, with suitable expanded metal or other reinforcement, but it is interesting to note in

the early experiments conducted by Mr. Ripley, which I was fortunate enough to see, that the concrete protection was held in place by driving nails, the heads of which projected from the surface of the pile. These nails were driven thickly over the entire surface about 3 or 4 ins. apart on centers. I do not think much has been done on this type of pile.

Another interesting type of combination pile construction was built at Long Island City some years ago, where the Standard Oil Company of New York had a wharf which was destroyed by fire at one of their refineries, only that part of the piles below the water level being left, the deck of the wharf with all the bracing being burned off. It was decided to rebuild this structure with a permanent wharf which would be fire resisting. After considerable study it was decided to use reinforced concrete, building a structure on top of the old piles which were left. The old piles were sawed off at a uniform level and the tops were capped with a series of concrete beams and braces. This construction was extended up to the desired height, with reinforced concrete columns at each pile, and on this structure was built a reinforced concrete deck, making an effective wharf which is in use to-day and at which large steamers dock to receive their cargoes.

On page 199, under the heading " Selection of Type of Pile," Mr. Gow refers again to the Simplex pile. I think it would be of interest for your members to know that up to the time, a little over a year ago, when comparative records were prepared, more piles had been driven, taking into consideration the whole world as a territory, under the Simplex system than under any other distinctive system of concrete piling. The percentage driven in the United States and Canada is not so large perhaps as some of our competitors, but when taken in the aggregate, as above stated, and with the whole world as a field, I think the Simplex system stands well in advance of the field for the number of feet of penetration of piles driven. The results cited above have been obtained not only by the efforts of the engineers and contractors operating, using the Simplex methods in this country, but are also due to the progressive methods employed by foreign engineers and contractors in England, Russia, France,

Italy, Greece, Belgium, and Germany, who have operated in all parts of the world using Simplex methods successfully.

On page 199, reference is made to the built-in-place piles which leave their shells permanently in the ground. Speaking of the tapered pile, I think it is proper to note that the value of the thin sheet-steel shell (No. 16 or No. 18 gage metal) which is drawn over the driving form is doubtful when driving in

Courtesy of New England Foundation Co., Inc.

Fig. 23.

Simplex Concrete Piles driven into the wall of abandoned gas holder (pit type) at the Central Station, Boston Consolidated Gas Co., Roxbury, Mass., for stack foundation.

Note the center row of piles, which are driven into a stone wall about 10 ft. 0 ins. deep. Piles were about 30 ft. 0 ins. long and were driven successfully without injury.

bowlder, hard gravel or shingle formation. At these times it is practically impossible to drive without rupturing this thin metal, thereby destroying its much advertised effectiveness as a protective shell. In water-bearing soil it is almost impossible

to keep water out of this type of pile, or, in fact, any pile, unless the end is calked water-tight. All cast-in-place pile-driving equipment used by contractors driving other systems carry special syphons to remove the water which may get into the pile form after driving and before concreting. In using the Simplex system we never have trouble of this kind, so do not have this device on our work. It is impossible to pour a concrete pile successfully in a form which contains water. To use a phrase of one of our friends driving another system, "*That is what I call well-washed concrete.*"

It is interesting to note what seemingly great difficulties can be overcome when driving cast-in-place piles which use heavy, rigid, driving forms and heavy cast-iron points such as are used in the Simplex system.

We drove Simplex piles for the Boston Consolidated Gas Company for a boiler house, power house and radial brick chimney. At the time we took the work, which was let to us on a competitive basis, we were told that we might strike obstructions which would make the driving very difficult. During the driving, we discovered that the piles for the stack were directly over the outer wall of an old-style pit gas holder which had been built within a brick building. This outer wall was the foundation for the brick wall forming the sides of the building. The wall was dry laid and was built of Boston bluestone. Piles were driven in the desired location without regard to the obstructions known to be there. Several piles penetrated this wall for its full depth, which was about 10 ft., without great difficulty, and were found to be perfect in every particular. Other piles were driven through the brick bottom of the holder, which was about 28 ft. below the surface. This bottom was hard burned brick laid on cement mortar and was about 12 ins. thick. This job is standing to-day without a crack or settlement, vindicating the judgment of the engineers in using this type of construction.

Mr. Gow refers in his paper to the use of reinforced concrete piles in wharf construction. There has been driven within the last two years, at Delara, Peru, a reinforced concrete pile wharf, some details of which were rather interesting.

This wharf was built in open water, using concrete piles driven to bedrock. As the material overlying the rock was constantly shifting, owing to the action of the currents and heavy sea, the rock was at times exposed, not offering any secure anchorage for the point of the pile. This difficulty was overcome by adopting the following method: The pre-cast pile was cast with a 2-in. pipe the whole length set in the center or long axis of the pile. After curing a specified time, the pile was taken from the casting bed and hoisted into the gins for driving. The piles were driven in the usual way to refusal, then they were stay-lathed to hold them in position. A steel drill rod with bit was lowered down the 2-in. pipe in the pile. This bit was churned up and down until a hole several inches deep was drilled in the rock. This drill was then removed and a steel pin was dropped down in the 2-in. pipe and grouted, thus pinning the point of the pile to the rock.

Mr. Linton Hart.* — Mr. Clarke spoke on the use of pre-cast concrete piles. We drive a great many such piles, notably in the district about Baltimore and in the southern waters where the concrete is not affected by the freezing action of the water due to the porosity, as might possibly be the case in northern waters when due care is not taken in making a proper mix to prevent undue porosity. These piles have been made in various shapes and sections, reinforced in different ways according to the handling they were to have and the use to which they were to be put. Some of the longest of these that have been driven in Baltimore waters were made 18 ins. square and 61 ft. long; they were driven for the foundation of a concrete pier at the United States Naval Academy, Annapolis, Md.

Mr. Clarke also spoke of pinning pre-cast piles to rock by drilling into the rock and dropping a cast-steel pin through a hole left in the center of the pile down into the hole drilled into the rock. This method was used to a considerable extent in the concrete sheet pile bulkheads along the New York State Barge Canal Terminus, and also used with considerable success in Chicago at the plant of the Sefton Manufacturing Company, on some bulkhead construction there.

* Representative of the Raymond Concrete Pile Company, 53 State Street, Boston.

Mr. Gow has brought out in his photographs an illustration of a pile-casting plant used by William L. Miller, of Boston, on his work for the Recreation Pier in Baltimore. This method of making up forms in one place, casting the piles and then, after they are set, moving them to the storage pile, has advantages which I do not think were brought out by Mr. Gow. We are now casting some piles by this method for use at the Bethlehem Steel Company's plant at Sparrows Point, Md., and we find that, due to the use of that particular system of casting, the seasoning process is speeded considerably over the other method of handling pre-cast piles, which is known as the " En Block " method. In this method, alternate piles are cast, and, after being stripped, a film of heavy grease is painted hot over the surface between the piles, thus preparing a form for the piles which are cast in between, the distance between the sides of the piles first cast being equal to one dimension of the pile. It is easy to see that where the surface of the cement is filled with a heavy hot grease like this, and one pile cast alongside and another cast on top, that the seasoning process is considerably held back.

In regard to cast-in-place concrete piles, there are three types, as you have already been told, which are commonly used in this country. These are the Raymond pile, which was the first to be developed; the MacArthur or Pedestal pile; and the Simplex pile. The advantages of the Raymond system consist in the speed with which the work can be done, the ease of inspection, the fact that every pile can be properly inspected from top to bottom before a load is superimposed, and the fact that the steel shell which is left in the ground prohibits undue strains on the shaft of green concrete, due either to back pressure in the ground or to the driving of adjacent piles. Dirt and other extraneous matter is prevented from mixing with and weakening the concrete which is to carry the load.

We have recently been experimenting with a new type of pile which Mr. Gow has not spoken of, known as the Composite Pile, which we have gotten up in order to enable us to reach to any depth. There have been composite piles driven previous to this as combinations of a wood pile with an unprotected concrete column made in somewhat the manner that the Simplex

and MacArthur piles are made, but this pile of which I speak is a combination between a Raymond pile and a wood pile. The joint between the concrete and the wood is made solid with bond bars which are driven into the wood and set also into the concrete, and tests have shown that the strength of this joint is about 70 per cent. of the resisting moment of the wood pile 2 ft. below the joint. There is no economy in the use of such a pile where a concrete pile from 30 ft. to 40 ft. long could be used instead, and the loads used differ materially with the kind of soil through which the concrete shaft and the wood shaft are driven. We have driven a number of these piles in meadows of New Jersey where they have gone down to 50 ft. or 60 ft., and they have been tested to a load of 120 000 lbs. with very good results.

The Composite pile is not a new idea in itself, but the use of a Raymond shell to form the concrete column on the top of the wood pile is a development of the early types of composite pile driven, and an improvement on them.

In regard to the tubular pile which Mr. Clarke has just spoken of, it may be interesting to know that the old New York Postoffice, which is built on stone footings, now entirely stands, for its whole uptown end, on piles of this kind.

This work was done by Frederick L. Cranford, Inc., of New York, under the direction of Mr. James C. Meem. These piles have all been jacked down to sand, using the columns of the old postoffice to jack against, and then have been dug out and filled with concrete. In digging out these piles they used a miniature orange-peel bucket which has been developed for this particular purpose. Each of these piles after having been concreted and set for a proper length of time has been tested for load by an hydraulic jack, and it has been found that there is an initial settlement varying from a fraction of an inch to considerable settlement before finding solid bearing. This initial settlement has been taken up by the jacks on all piles underneath this building, and I think that Mr. Meem will have some very interesting reports to make on the results obtained on that particular type of pile when this particular section of subway work is finished.

Mr. Harry E. Sawtell.* — Mr. Gow's paper is admirable and will help us to gain a better understanding of this important subject.

It seems reasonable to assume that the greater part of all concrete piles used are uninjured and doing the work imposed upon them, as a great many important structures are safely supported by them.

It can also be assumed that most groups of any kind of piles contain some which are not good and which do not perform their part of the work; and yet how many designs include extra piles to make up for this condition?

It is seldom done, owing to the expense of added piles and to the uncertainty of the number which may be bad.

In order that the number of bad piles may be reduced to a minimum, it would seem necessary to gain a thorough knowledge of the soil by means of borings rather than to trust to test piles; to select the proper pile for the place and to give the construction work thorough supervision.

The need of exploration of the soil cannot be stated too strongly, as a knowledge of the soil reduces the largest factor of uncertainty to a minimum.

When selecting piles for soils having a compressible or plastic nature, such as medium or soft clays, some sands, etc., it should be kept in mind that settlement must be expected more or less continuously, and that the settlement can be reduced considerably by spreading all loads over large areas, thus reducing the unit load.

This can often be accomplished better by using a greater number of wood piles having one half to one third the value of concrete piles.

If properly selected and driven, there seems to be every reason to expect as small if not a smaller percentage of poor wood piles than poor concrete piles.

The fact that bad piles are probable in all types of cast-in-place or driven piling makes the "safety factor" or "degree of security" all the more important.

It is the custom in Mr. Chas. T. Main's office to have load

* Structural Engineer, with C. T. Main, 201 Devonshire Street, Boston.

tests made whenever possible, in order to assist in the determination of values. It seems desirable in most designs for first-class structures to get piles having practically no settlement under working load, and a limited settlement under two and one-half times the working load. This maximum may vary from $\frac{1}{4}$ in. to $\frac{3}{4}$ in., depending upon the character and occupancy of the building.

It is also our custom to note the change in settlement of a pile being tested when both putting on and removing an amount of load equal to the total live load which may be added or removed from the building in service.

If all piling is placed with care, and a safety factor of at least $2\frac{1}{2}$, as above defined, is obtained, we can feel quite sure that if a small percentage of bad piles has been driven, no marked settlement or failure will be obtained.

For medium clays, which are found in a great many places in New England, we have found that the best guarantee against troublesome settlements is a deep embedment of the pile.

Mr. Gow speaks of the protection afforded by the shell, of the Raymond type of pile, against lateral strains in the soil, but we have found that even these piles have become occasionally distorted before the concrete has set hard.

This is liable to take place at the level of a practically incompressible stratum of soil by the driving of successive piles.

It is my opinion that to gain a greater degree of security, piles should be spaced at least 3 ft. center to center, and more if it is thought desirable to develop the full strength of the soil.

The driving of built-in-place piles should be arranged so that successive piles produce the least lateral pressure on newly poured piles.

Mr. John T. Scully.* — I do not want to make any statements that would in any way convey the idea that I am trying to advertise our proposition, but since the representative of the Simplex has spoken in regard to the paper, I would like to state one or two features that are particularly important to me, and particularly interesting to me, and I think would be interesting

* President John T. Scully, Inc., 185 Devonshire Street, Boston, representing the MacArthur Concrete Pile and Foundation Company.

to the gentlemen here, in reference to the MacArthur concrete pile — the pedestal pile — which I represent in Massachusetts.

I had been identified with the wooden pile driving for some forty years or more, and, seeing the trend of events, I felt that if I were to continue in the piling and foundation business, it would be necessary for me to follow along the lines of a concrete pile proposition, and for a year and a half I have been identified with the MacArthur concrete pile.

The method of driving is somewhat different at the present time from that which was shown on the screen. We use in most cases the cast-iron point with the 16-in. diameter shell, and the plunger in the inside which does *not* extend beyond the shell. It is the same length as the shell. The shell and the plunger are driven together.

When the proper stratum is reached, the plunger is withdrawn and a small batch of concrete is put into the tube; then we replace the plunger. We notice this, that the plunger is perhaps 3 ft. out of the shell. We then raise the shell 6 ins. or perhaps a foot and then drive with the steam hammer, and the concrete is driven out of the tube. Where the strata is comparatively soft, it goes quite easily. The softer the strata, the more quickly the concrete takes its shape.

After the bulb is formed, we then fill the shell full of concrete and place the plunger — weighing with the hammer on top four or five tons — on top of the concrete and withdraw the shell. The weight of the plunger simply tends to force the concrete into place and prevent it arching, which to my mind is one of the most important features of the MacArthur concrete pile. We have the bulb that has been made and we have the weight of the hammer on the concrete which holds it down and prevents it from arching while the shell is being withdrawn.

Some time ago there were some interesting experiments performed at the Pennsylvania State College to determine the distribution of the forces set up in the earth due to a bearing pile transmitting its load to the soil.

Lines of force were drawn through points below the pile where the resistance to the pile load were of equal unit value. Of course the line showing the greatest unit resistance was a

straight line directly below the center of the pile, but the lines showing the lesser unit resistance took a bulb shape from the tip of the pile. The line showing the least unit resistance included all the lines of greater unit resistance. This line was an exact duplicate of the shape of the MacArthur pedestal; and leads me to suggest that if, under the ordinary 14-in. or 16-in. concrete pile without the bulb, the lines of resistance set up in the earth take the shape of the MacArthur pedestal, how much greater the resistance when the concrete bulb is put in.

I think that in the concrete pile business we have all profited by the mistakes of the past and that we know, not from experiment but from actual results, pretty closely what the pile will stand.

Mr. R. A. Hale.* — In driving through sand and gravel containing small bowlders, I should like to inquire how they overcome the difficulties on striking a bowlder which cannot be moved easily.

Mr. C. R. Gow.† — I believe that you will experience the same trouble from such a cause whatever the type of pile, whether wood, concrete or steel. If the bowlder is of sufficient size to resist lateral displacement, the pile point is reasonably sure to stop at that elevation.

Regardless of the attractive advertisements which frequently describe how steel piling and other types are driven through bowlders and even into solid rock, I have yet to be convinced that such action ever occurs except perhaps in a few instances where the rock is soft or more or less disintegrated.

The best method which I know of for displacing bowlders below the surface of the ground is that of utilizing the water jet.

In making test borings through coarse gravel we frequently encounter stones too large to permit of their being washed up through the pipe. By working the wash drill past them and eroding the fine material from below, it is sometimes possible to drop these stones down into the cavities thus formed.

In the construction of the foundations for the new Thames

* Principal Assistant Engineer, The Essex Water Power Company, Lawrence, Mass.

† Author's closure.

River Bridge, at New London, Conn., now under way by the Holbrook, Cabot & Rollins Corporation, it has been necessary to sink some very large open caissons to a maximum depth of 140 ft. through silt and gravel. They are sunk by dredging with grab buckets through open pockets. Occasionally a bowlder is encountered which is too large for the bucket to handle.

To displace such bowlders, Mr. Rollins has installed a jetting apparatus of unusual size. A 1 200-gal. fire underwriters' pump operated by a 250 H.P. boiler delivers water to a 4-in. jet pipe at the rate of about 1 000 gals. per minute under a pressure of 150 lbs. per square inch. When this apparatus is operated and the jet pipe — handled by a derrick on lighter — is lowered alongside of a bowlder, a large cavity is at once created into which the bowlder rolls. By repeating the operation for a few minutes the bowlder can be buried to a depth of 15 or 20 ft. below its original position.

If bowlders encountered in the driving of piles cannot be removed by this method or by blasting, it will usually be necessary to drive another pile alongside at a sufficient distance to clear the obstruction.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

LINES AND GRADES IN TUNNELS OF SMALL DIAMETER.

BY HENRY B. PRATT,* MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

IN the construction of two tunnels for the Edison Electric Illuminating Company of Boston, one under Fort Point Channel and the other under the Reserve Channel, it was found difficult to give lines and grades in the usual manner, with the transit set up on the tripod, owing to the fact that the diameter of the tunnels, which was only 7 ft. on the inside, did not permit of setting up the instrument without stopping the passage of cars on the construction track. The delay caused by stopping these cars was very serious, as it often meant that the whole gang on that end of the tunnel, not only in the heading but also in the shaft, lock and head house, was obliged to suspend operations until the cars were given free passage.

In order to avoid this delay a method was devised by which the instrument could be attached to the roof of the tunnel in an inverted position (see figure), allowing the passage of the cars beneath, the clearance between the top of the cars and the lowest part of the transit being about one foot. In order to use the instrument in this manner it was necessary to so arrange the level tube that the bubble could be seen when the instrument

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NOTE. This paper will not be presented at a regular meeting of the Society, but discussion is invited, to be received by W. L. Butcher, Editor, 14 Beacon Street, before January 10, 1918, for publication in a subsequent issue of the JOURNAL.

was upside down and the vertical arc in its normal position. A Buff transit was used, equipped with a 180-degree vertical arc, and after having the instrument put into good adjustment it was set up on the tripod, the telescope leveled, and a horizontal line marked about 50 ft. distant, coinciding with the horizontal

TRANSIT IN INVERTED POSITION

cross-hair in the instrument, with the vertical arc reading zero. The level tube beneath the telescope was then removed and replaced in an inverted position, the telescope rotated vertically so as to bring the level tube over the telescope with the graduations uppermost, and the level tube so adjusted that when the cross-hair was on the mark the bubble was on center. Now by rotating the telescope back to its normal position and setting

the vertical arc on zero, the telescope was brought perpendicular to the vertical axis of the instrument with the bubble on center, although not in a readable position until the instrument was turned upside down. If the transit were equipped with a complete vertical circle, this same object could have been accomplished by rotating the telescope vertically 180 degrees from normal and clamping with the vertical arc, reading that figure which would bring the bubble into a readable position when the transit was turned upside down.

Wooden blocks about 8 in. square were built into the roof of the tunnel as the work progressed, being placed at intervals of about 200 ft. To these blocks were attached metal sockets, such as the transit is screwed to when cased, care being taken to set them approximately on line. When giving line in the tunnel, the transit was screwed to one of these sockets, the vertical arc was set on zero and the instrument leveled by using leveling screws and observing the telescope bubble, which was now above the telescope with the graduations uppermost. It required some practice to level the instrument, as the screws had to be turned in the opposite direction from what they would be if the transit were in an upright position. The instrument was revolved horizontally in leveling, in the same manner in which a Wye level is revolved when being set up. In order to bring the transit on to the exact line, it was slipped laterally on the sliding head and brought on to line by observing two points which had previously been accurately established farther back in finished tunnel. The telescope could now be rotated vertically and line given ahead in the usual manner. After bringing the instrument on to line, a plug was set in the side of the tunnel at the level of the telescope and an offset read to the center of the instrument in order that the transit could be set on line at any other time without making observations.

When giving grades the telescope was leveled, the height of instrument determined and rod readings taken in the usual manner. After once obtaining the height of the instrument on a "Set-up" on any particular socket it was found that the instrument would be near enough to the same height on successive set-ups on this socket to allow of giving grades without

a further reading on the bench except in the case of establishing a bench ahead.

In order to prevent wear between plates of the transit due to the liability of particles ot dirt working into the joint, the two plates were kept constantly clamped. As a further precaution, some heavy grease was run into the joint so that when the transit was screwed to the roof of the tunnel particles of mortar which would fall on the instrument would be prevented from working into this joint which was then exposed. As the tunnel in which this method was used was straight, there was no occasion to turn any angles or to set the instrument on a point, correct both for line and distance. If it were necessary to run out a curve using an instrument in this manner, it could be accomplished by giving tangent offsets, instead of reading angles, which would be somewhat difficult to do with the instrument upside down. If it were required to set the instrument correct both for line and distance, it could be done by setting two offset plugs, one on line with an offset for distance, the other at right angles to line with an offset to line.

In using a transit in this manner it is well to tighten the nut at bottom of spindle, so as to take up the play between the plates and also to make the instrument secure, as almost the whole weight of the transit is carried by this nut.

This method of running lines and grades was found to be very satisfactory, as the engineers were enabled to do their work without feeling hurried, as they would have felt if they knew that they were causing the contractor a serious delay. The writer is indebted to C. W. Alexander for his able assistance in perfecting this method of tunnel survey.

MEMOIR OF DECEASED MEMBER.

STANLEY ALFRED MILLER.*

DIED MAY 13, 1917.

STANLEY ALFRED MILLER was born in New Orleans, La., on May 27, 1882. He was educated at local schools and at the Louisiana State University.

He passed through the grades of rodman, levelman and instrumentman and became assistant engineer on sewers, levee work and railways, and when nineteen years old was assistant engineer to the Board of Public Works of Mobile, Ala.

As assistant to various consulting engineers he was employed on the survey, design and construction of sewers and water-works for Baton Rouge, La.; Mobile, Ala.; Dallas, Tex., and Ardmore and South McAlester, Okla.

In 1904 he was resident engineer on the Chihuahua & Pacific Railroad, and in 1905 was with S. Pearson & Son, Ltd., on port works at Puerto, Mexico. Next he worked for the Mexican Light and Power Company near Necaxa, Mexico, in 1906, in charge of Earth Dams Nos. 1 and 3 and Tunnel No. 1.

He constructed a seven-mile sewer for Paducah, Ky., and paving and sewerage for Cairo, Ill., in 1906 and 1907, and was assistant engineer on hydroelectric projects in California and Colorado in 1907 and 1908.

For the next three years he was in charge of the Azua Irrigation Survey in Santo Domingo. The writer helped him pick assistants for this work, and visited him several times during its progress. It was very hard work, all supplies and water having to go by pack train. The work was finished in spite of revolutions and other troubles.

He next took charge of the location of fifty-five miles of improved highways for Copiah County, Mississippi, and the

* Memoir prepared by William H. Balch, who states that he has taken his facts largely from the able memoir of Mr. Miller by Mr. Vernon L. Havens, Proceedings of American Society of Civil Engineers, August, 1917, p. 1407.

construction of a part of the work. He then went to the Argentine Republic, and then entered the employ of the Uruguay Railway Company, in charge of railway location and construction, and the building of a reinforced concrete wharf.

From October, 1914, to December, 1916, Mr. Miller was engaged in general consulting practice at his home in Paducah, Ky. He designed sewers for the city, and reported on drainage projects in Kentucky, a hydroelectric plant in Mississippi, and rates for a public utility corporation. He became well known in Kentucky through his earnest efforts to improve the status of the engineer and to increase the interest in good roads. He built up a good practice, which was continued during his last absence in Santo Domingo.

In December, 1916, he sailed to La Romana, Santo Domingo, to "study a couple of rivers for hydroelectric and irrigation development" for the South Porto Rico Sugar Company at Central Romana. This work, like his previous work in Santo Domingo, meant living in a camp at a distance from the town and plantation. It was an unexpected pleasure to the writer to meet Mr. Miller at La Romana on April 8, when he delayed his return to camp so that we could have a long talk. We planned for the writer to visit the camp, when his work permitted.

On April 15 Mr. Dillingham and Mr. Maxwell, of the South Porto Rico Sugar Company, visited his camp, with a party including Miss Dillingham and Miss Davis. On May 13 we were shocked to hear that Mr. Miller and his assistant, Mr. E. Hawkins, had been killed in camp early that morning by bandits. We could not believe it was true, but a party under Lieutenant Hunter, U. S. M. C., with Dr. Watkins (formerly surgeon, U. S. A.), found the report true and were able only to burn the bodies and return to La Romana.

Mr. Miller and Mr. Hawkins were killed as an act of wanton revenge by a band of over one hundred (220, when captured, according to official report) outlaws, on account of losses they had sustained in conflict with United States marines. The outlaws rushed his camp in the early morning and took the men away, killing them about an hour later. Mr. Miller ex-

plained to the bandit the nature of his work and its non-military character, but the reply was, "Los Americanos están buscando mi vida, y yo voy á tomar la suya." ("The Americans are trying to take my life, and I am going to take yours.") His last request, that he be permitted to write to his wife, was denied.

He met his death bravely, as a soldier of the world's advance. Only the future can show us how very important was his work of helping increase our sugar supply at a critical time. His loss will be most keenly felt by all his associates and acquaintances, to whom his high ideals had always been an inspiration.

Mr. Miller was married to Miss Ann Bradshaw, of Paducah, Ky., who, with their daughter, Stanley Ann Miller, born six weeks before her father went to Santo Domingo, survive him. He is also survived by his father and mother, Mr. and Mrs. W. R. Miller; his brother, Mr. W. R. Miller, Jr., and his sister, Mrs. W. Molton Evans, all of Baton Rouge, La.

Mr. Miller was a member of the New England Water Works Association, American Society of Civil Engineers, Boston Society of Civil Engineers, Sigma Alpha Epsilon fraternity and Rotary Club of Paducah.

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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

RUSSIA, — AN OPPORTUNITY FOR AMERICAN ENGINEERS.

By George C. Whipple,* President, Boston Society of Civil Engineers.

Having been asked to tell the members of the Boston Society of Civil Engineers something about my work during the past summer as a member of the American Red Cross Mission to Russia, I gave an informal talk at the regular meeting of the Society held November 21, 1917. This related chiefly to facts and impressions which I gathered during the journey through Siberia to Petrograd and Moscow and my visit to the Russian army at the front.

The following notes give in substance what was said at that time.

The Call to Russia.

On the 19th of June, at eleven o'clock, as I was getting ready to go to bed at my home in Cambridge, I received a long-distance call from Mr. Henry P. Davison, chairman of the War Council of the American Red Cross Society, who told me that the President wanted me to go to Russia, and asked if I could be in New York to attend a conference at ten o'clock the next morning. I then and there decided that I would go. There was just time to dress and catch the sleeper.

In New York I met Dr. Frank Billings, who was to head

* Major and member of the American Red Cross Mission to Russia.

the Mission; Mr. Wm. B. Thompson, who had generously offered to finance the expedition as well as to accompany it; Prof. Henry S. Sherman, of Columbia; Prof. C.-E. A. Winslow, of Yale, and others. A few days later Mr. Davison came up from Washington, and everything was settled so far as I was concerned. Meantime Dr. Billings was securing other members and making the detailed arrangements for the journey. The date of departure was set for June 29 from Boston and New York, June 30 from Chicago. Within a week's time uniforms had to be made, passports and commissions secured, transportation arranged through to Russia, and medical and other supplies obtained from a score of firms scattered over many cities and concentrated so as to leave Vancouver on the *Empress of Asia*, on July 5. Besides this, the members of the Mission had to arrange their personal affairs and prepare for an absence of unknown duration. It seemed like an impossible task; but it was done. Every man was ready on time, and the supplies were on board. Too much credit cannot be given to the officials of the railroads, all the way from New York to Vancouver, who broke rules and cut red tape right and left, under the magic influence of the red cross symbol. Never before, perhaps, were cases of freight carried in the compartment cars of the Twentieth Century Limited. Never before, perhaps, was a Canadian Pacific limited train ordered to stop to pick up a freight car which had missed its connection.

The First Meeting.

The first meeting of the American Red Cross Mission to Russia was held in the Blue Room of the Hotel Vancouver, on the Fourth of July. There were twenty-nine in all, two lieutenant-colonels, twelve majors, six captains, six lieutenants and three orderlies. Beneath the American flags which decorated the room, these men pledged obedience to their commander, Colonel Billings, and their loyalty and their lives to the cause of the American Red Cross in Russia. After drinking a toast to the health of the President of the United States, Colonel Billings, holding up his glass of water, said, " I ask you all to pledge with me that until we return to America this shall be the

only beverage of the Red Cross Mission." The Mission then and there went on the water wagon, and perhaps no other single thing attracted so much notice or received such favorable comment in Japan, Russia and China as this abstinence from intoxicating liquors. The Japanese Red Cross Society who entertained the Mission at dinner at Tokyo had prepared an elaborate spread of glasses, and were much surprised to find that they would not be used. The matter was discussed at dinner, and the sentiment of the Japanese was that they too would adopt the custom at their Red Cross dinners, and when later on they entertained the American Red Cross Mission to Roumania they put the idea into practice. An amusing event happened at our Red Cross dinner. Not wishing the Japanese to feel offended at our failure to partake of their hospitality, Colonel Billings at the conclusion of his speech announced that the rule would be suspended in order that the health of the Japanese emperor might be appropriately drunk, but by that time most of the champagne glasses had been filled with tea, so the health of the emperor was drunk in the national beverage.

At this point mention should be made of the men who composed the Mission, for I want to bear witness that no better men, no more congenial companions, were ever gotten together. I regard it as an honor to have served with each and all of my colleagues.

First in order was Lieut.-Col. Frank Billings, of Chicago, physician, president of the American Medical Association, professor of medicine in the University of Chicago, and head of the great medical school about to be founded there, who had been twice to Russia and who was altogether the best equipped man in America for his important mission. Next was Lieut.-Col. Wm. B. Thompson, one of the big business men of the country, director of the United States Federal Reserve Bank of New York, well known not only for his successful business enterprises but for his benefactions to educational institutions.

The twelve majors represented the specialists of the Mission. The medical men were Dr. Wm. S. Thayer, professor of medicine in Johns Hopkins University, experienced in general medicine and in hospital work; Dr. D. S. McCarthy, fellow of the Phipps

Institute, Philadelphia, specialist in the study of tuberculosis, who has seen active service in Europe in the care of prisoners during the present war; Dr. Wilbur E. Post, assistant professor of medicine in the Rush Medical College of Chicago, experienced in the problems of industrial hygiene, who acted as "family physician" to the members of the Mission; Dr. Orrin S. Wightman, professor of clinical medicine, New York Polyclinic Hospital, who devoted his attention chiefly to photographic work, including moving pictures for the publicity work of the Mission; Dr. Malcolm Grow, Washington, D. C., major in the U. S. Medical Officers Reserve Corps, attaché, — familiar with certain problems through previous service in the Russian army.

The majors chosen for special service were Henry J. Horn, Boston, Mass., member of the corporation of the Massachusetts Institute of Technology, expert in railroad transportation; George C. Whipple, Cambridge, Mass., professor of sanitary engineering in Harvard University and the Massachusetts Institute of Technology, especially assigned to problems of military sanitation; Raymond Robins, Chicago, well known as a social economist and progressive political leader, expert in social relief work and intensely interested in the present political conditions in Russia; Dr. Henry C. Sherman, professor of food chemistry in Columbia University, New York, specialist in food problems; C.-E. A. Winslow, professor of public health in the Yale Medical School, specialist in public health administration and the problems of infant welfare; Harold H. Swift, executive head of Swift & Co., Union Stock Yards, Chicago, specialist in food supply; Thomas D. Thacher, lawyer, firm of Simpson, Thacher & Bartlett, New York, secretary of the Mission.

The captains were James W. Andrews, of St. Louis, accountant, the treasurer of the Mission; Allen Wardwell, lawyer, firm of Stetson, Jennings & Russell, New York, secretary to Colonel Billings, promoted to the rank of major while in Petrograd; Robert I. Barr, vice-president of the Chase Securities Company, New York, in charge of the supplies; William Cochran, New York City, assistant to Major Horn in transportation; H. Malcolm Pirnie, firm of Hazen, Whipple & Fuller, consulting engineers, New York, assistant to Major Whipple in military

sanitation; Henry S. Brown, journalist, New York, publicity.

The commission included men capable of giving judgment and planning action in any line of work likely to be undertaken by the Mission in Russia.

The Journey to Russia.

The journey to Russia and back to America was a remarkable experience. We left Boston and New York on June 29, and arrived in Petrograd on Tuesday, August 7, after a journey of nearly six weeks. Of this time, five days were spent crossing the American continent, three days in Vancouver and Victoria, ten days on the Pacific, eight days in Japan, one day on the Japanese sea, one in Vladivostok, thirteen days on the Trans-Siberian railway.

If time permitted, it would be interesting to tell in detail the story of this journey, of the magnificent scenery in the Canadian Rockies, of the Russian lessons, the setting-up drills, and the vaccinations on the *Empress of Asia;* of the wonderful address of Major Robins in the cabin which held us spellbound as he related the story of his life and his work in the Klondike; of the week in Japan, with its novel sights, its bountiful entertainments by the Japanese Red Cross officials, its side trip to Nikko, the Japanese dinner given by the celebrated Kitasato, and the final ride across the mountains to the lovely harbor of Tsuruga; of the beautiful moonlight sail across the Japan Sea, when the members of the Mission gathered on the deck and sang songs till midnight; of the hustle at Vladivostok to load the supplies; of the special Imperial train of thirteen cars once used by the Tsar, and including the very car in which, only four months before, he had presented his signed abdication to a committee of the revolutionists; of the interesting sights in Manchuria and Siberia, the swim in the Ingoda River, the magnificent Lake Baikal, six thousand feet deep, around which we traveled all one day; of the committee work in the staterooms during the long days and the poetry and the mock trials in the lounging-room during the short nights; of the speeches to the soldiers, and the cheering and the hugging and kissing at the station

platforms; of the enthusiasm of every one over the great land of Siberia, a land not of barrenness and hardship, but a great, beautiful, wonderful land, with fertile soil and splendid forests, — a land of cattle and pastures, a land of splendid folk, a land of promise. One could write a book of all this, but such books have already been written, and these things were for us merely by the way, for back of it all we realized that it was war time and we were on a war mission.

Finally we arrived at Petrograd. We were met at the station by Ambassador Francis and other Americans, and by representatives of the Russian Red Cross. In fact, although the Russian Government had furnished us with the Imperial train and military guards, the same train, by the way, in which the Root Commission had traveled east on their return to America, we had been the guests of the Russian Red Cross through Siberia. Representatives of this society had met us at Vladivostok, and acted as both guides and interpreters. For a few days the Mission made its headquarters at the Hotel de France, but later better and more permanent quarters were secured at the Hotel d'Europe, just off the Nevsky, in what is practically the center of the city.

The Return Journey.

The Mission remained in Petrograd for five weeks, although during this time side trips were made by some of the members to Moscow, to Ekaterinoslov, to Archangel, and to the west front of the army near Minsk. On September 11, Colonel Billings, with five majors, two lieutenants and two orderlies, left for America, leaving the other members in Petrograd as a permanent staff, to remain throughout the war or as long as their services may be required. A few of them have since started for America, but others have taken their places.

The return journey was even more delightful than the journey out. A special car on the regular weekly express took us to Harbin. It was September, and Siberia was yellow with grain, yellow also with the turning leaves of the white birch and Siberian larch, and we were more than ever impressed with the

resources of the land. We said, over and over, "This is a land of gold." Arrived in Harbin on September 21, we changed cars and crossed Manchuria, with its fields of tall kaoliang (millet, or Kafir corn), passed through Mukden, the seat of the great battle in the Russo-Japanese war, and reached Peking on Sunday, September 23. There we had a glorious week, every moment filled with sight-seeing and entertainment. These included luncheons by our American ambassador, Mr. Paul S. Reinsch; a formal dinner to Admiral Knight's party and our own, the ceremony of laying the cornerstone of the new Rockefeller Hospital, visits to the Forbidden City, the summer and winter palaces, an American dinner by Mr. Finch (a mining engineer associated with Colonel Thompson), and boundless courtesies from every American in the place.

Two of us went to Tientsin to speak at a Red Cross meeting, but instead of the meeting we investigated the great flood, and Colonel Billings and Minister Reinsch sent a cable to Washington in regard to American aid for the million homeless people. As a result of this, the American Red Cross Society sent over a large fund to be administered by Mr. Roger Greene. An extremely pleasant feature of the visit to me was that of meeting a former student, Surg.-Gen. S. H. Chuan, director of the Chinese Army Medical College. Dr. Chuan and several hundred of his students were all busy with relief work for the flood refugees.

The floods prevented our return via Shanghai, so on September 28 we went back through Manchuria, Korea and Japan. This gave us a day at Seoul. At Osaka we encountered the flood caused by the great typhoon which did so much damage in Tokyo. We were obliged to pass one of the great railroad breaks in boats for over half a mile.

We reached Tokyo October 4, sailed from Yohohama October 6, arrived in Vancouver October 15, and in Boston, October 20, after an absence from home of four months less one week.

Points of Interest to Engineers.

I had opportunity to visit many engineering works. The mayor of Yokohama and the mayor of Tokyo extended the courtesies of the engineering departments of those cities. We saw the sand filtration plants in both cities, the new water supply and the proposed sewerage projects for Tokyo, the harbors, docks and shipbuilding plants. We visited the engineering school of the University of Tokyo, and I made an address to twelve hundred Japanese students at Aoyama College.

The Trans-Siberian Railway interested us. It is approximately 5 500 miles long, is substantially built, has a double track for perhaps a third of the distance. The double-tracked loop around Lake Baikal has been practically finished. This was heavy work, as it included over forty rock tunnels. The railroad stations and outbuildings are substantial and neat. The grades are heavy in places, the rails light, the driving wheels of the wood-burning locomotive small, the sidings infrequent and the operating sections small. Consequently, the speeds are low, station stops long, and the locomotive runs small. The present tonnage is far below normal; and freight has piled up at Vladivostok. It is said that, with changes in operation which can be easily made, the capacity of the road can be increased a third. But more rolling stock and more sidings, and ultimately a double track, are greatly needed. The engineers of the Stevens commission are now hard at work on this problem.

In Petrograd we found that the old sand filter of the water supply from the Neva had become outgrown and had been converted into an improvised mechanical filter, using bleaching powder and electrolyzed salt as a disinfectant. A new mechanical filter of German make, which involved the use of ozone, was in operation. This is perhaps the largest ozone plant in use, i. e., 13.5 million gallons a day. The engineer in charge is not pleased with it. It has proved to be very expensive, and is likely to be abandoned.

In Petrograd the sewers do not receive the solid fecal wastes. These are screened from the house drains at each house, collected in night soil carts, and carried to barges which dump them far down the river, or to a receiving station where they are

again screened through Reinsch Wurl screens and the solids burned in the adjoining refuse incinerator. The liquid portion of the house sewage flows to the sewers and is discharged through long outfall sewers, the storm overflow going to the canals.

At Moscow we found a most interesting sewage experiment station, one of the largest in the world, in which the latest methods of disposal, including activated sludge, are being studied by an able and enthusiastic engineering chemist, Dr. Serge Stroginov.

In China we were greatly impressed with the importance of the flood problem. It towers above all the other engineering needs of China.

The opportunities for engineering work of many kinds in all of these countries are tremendous.

Russia as We Found Her.

On our way to Russia we had heard all sorts of disheartening rumors. "The government was unstable; there was no government at all; all the officials were resigning; the soldiers were walking the streets of Petrograd, committing all sorts of crimes; there was no police; the army was disorganized; the Germans were liable to take the city at any moment; there was no food in the city; the railroads were not running; Senator's Root party had been assaulted; bridges had been burned; there was small chance that we should ever reach Petrograd any way." But instead of that, our train moved steadily onward through a friendly population, through fields of wheat and rye rich with harvest, and we reached Petrograd just when the general in charge of the train said we would.

In Petrograd there were no crowds. There were plenty of soldiers, loafing, to be sure, and there was practically no police protection, but nowhere was there disorder, nowhere were any discourtesies shown; and wherever we went, whether among officials, officers or soldiers, or among the people on the streets, we received only marks of kindness. The trolley cars and trains were crowded with soldiers, for they claimed the right of riding free. On the Neva and on the canals boat traffic was slight,

and very little trucking was being carried on in the city, but during the five weeks we were there there was a change. Barges, chiefly loaded with fire wood, were seen discharging along the canals; the winter's fuel supply was growing; street traffic increased; the streets were regularly cleaned; troops were seen marching, and long supply trains went through. The food supply was short, especially bread, milk, sugar and butter. Prices were high, and as the rouble fell in value from $23\frac{1}{2}$ cents to 14 cents (the normal exchange is about 50 cents) prices went higher. Bread lines could be seen every day, also chocolate lines, cloth lines and cigarette lines. But there were no riots; the people appeared to be well nourished, well clothed and well shod. The patience and orderliness of the men, women and children, their respect for each other's place in line, was most conspicuous.

We of the Mission had food enough, but not always what we wanted. Often we had a meager breakfast. Sometimes it consisted of black coffee, with no milk, sugar or bread. At best it consisted of black coffee with black bread, jam, butter and sugar. The black bread was sour, but occasionally we got what was called white bread, although this epithet was applicable only by contrast or courtesy. Luncheons and dinners were much alike, and consisted of soup, fish, and veal, chicken or game bird, with compôte for dessert, which modest meal cost between $2.00 and $3.00 a plate, American money. One of our majors picked up this bit of conversation which very well illustrates the conditions. He met a gentleman of pronounced Hebrew profile and speech, who had just returned from a visit to the front. The major said, "I suppose you saw plenty of excitement there." The reply was, "I should say I did see blenty of exzidement. I had to pay thirty r-r-roubles for my dinner, and zee next day it vas more, too." To offset the high prices, we paid no waiters' tips. Tips are taboo in a free country. The waiters regarded themselves as our equals, and would not condescend to take tips. They preferred to add 15 per cent. to the bill, and to be called "officiants." In short, we had no luxuries in Petrograd, but we had no hardships worth talking about.

One evidence of the revolution was the enormous number of

posters on the buildings. They covered the stores, the churches, the palaces, the bases of statues, the telegraph poles, the fences. Wherever a poster would stick, there it was pasted. This gave the city a very unkempt appearance. The old Russian flag was seen nowhere (although many think it will some day return), and in its place was seen the red flag of the revolution. This hung over public buildings, over the Peter and Paul fortress; while a small one had been placed in the hands of the bronze statue of Catharine the Great, in the park on the Nevsky. The old coat of arms, the double-headed eagle surmounted by a crown, had been stripped from public buildings, from signs and even from the railroad cars. In every way the people have tried to obliterate all recollection of the former hated government. Some of these attempts have been childish.

On the day following our arrival, an event occurred which did much to encourage us. This was the popular sale of liberty bonds. Petrograd was gala with booths decorated with flowers and bunting. Decorated automobiles and barges filled with young men and women went through the streets. There were bands and much enthusiasm. For three days the sale went on. The bonds were of small denomination, the cheapest being 20 roubles, or about $4.00 at that time. People on the street bought in large numbers. Many soldiers bought them. It reminded us of our own Liberty Bond sale and of the collection of the Red Cross Fund. The scenes in Fifth Avenue, New York, as I saw them, could be duplicated on the streets of the Nevsky. We have since learned that as a result of the sale in Russia the sum of nearly four billion roubles, or about one billion dollars, was secured.

Another sight, both sad and inspiring, was that of the Woman's Regiment starting for camp on the way to the front. A thousand young women had been training on the grounds of the Technical School; but one day, at seven in the morning, they held an open-air religious service, and marched away in heavy marching order, with full packs and complete camp equipment. The young women looked like boys. They were very young. They were splendidly drilled. They were doing this not because men were scarce, but because so many men were loafing instead

of fighting; and no one can deny that the spirit of these young women was sincere and patriotic; but to see the mothers with tears in their eyes, following their daughters beside the outgoing column as they marched across the canal bridge towards the Neva, was a sight to bring tears to the eyes.

Best of all, however, we found Russia sober. Vodka has almost wholly disappeared. Just as in our prohibition cities and states, alcoholic liquors are sometimes obtainable, perhaps more freely in the country than in the city, but I doubt if half a dozen drunken men were seen in Petrograd during our five weeks there. Personally, I saw none. The only place where I saw liquor openly used was at the tables of some of the officers at the front, and in our presence it was not used to excess. What would have happened if universal prohibition had not preceded revolution it is easy to imagine.

Russia's Part in the War.

In order to understand Russia's attitude in the Great War, it is necessary that one consider her history during the eighteenth and nineteenth centuries. This was a period of contest between autocratic and democratic powers the world over. The American revolution, the French revolution, the peaceful liberalization of England, the struggle for freedom in Italy, were some of the more conspicuous of these contests. At the beginning of the twentieth century, Germany, Austria and Russia alone, of the great European countries, were autocratic. Austria, the stronghold of autocracy under the influence of Metternich, had become subordinate to Germany. Russia became more autocratic as her government became Germanized. When Peter the Great reached westward for his ideals of civilization, he brought to his country a new strength, but he also allowed to enter a people who, when the time came ripe, would strangle the nation and use its great resources for its own foreign ends. From the time of Catharine the Great to the time of the last Tsar, Nicholas II, the Romanoff blood has been mixed with the German. The Russian court and the bureaucracy has been growing increasingly Germanic, the business world of Russia has been Teuton-

ized, the natural raw materials of the country have been shipped to Germany, and the false rulers have blocked the way to popular education and freedom of the common people. Against this stone wall of autocracy, the people of Russia — democrats, nihilists, anarchists, alike — have beaten in vain, and death or exile has been their reward.

There was a time, up to the early days of Bismarck, when the Russian and German autocracies were willing to aid each other against the rising tide of democracy, but during the last generation, when Germany began to show her desire to alone denominate Europe and began to treat Russia as a rival autocratic power, the Russian rulers gradually drew away from Berlin. Needing capital, official Russia looked to France and England, and gradually there resulted a cordiality and then an alliance with France. Meantime the last attempt at revolution, after the Russo-Japanese war in 1905, had disappeared, and Russian autocracy appeared to be firmly in the saddle.

When Germany sprung the trap in 1914, Russia entered the war, and almost to the surprise of the nation autocratic Russia and democratic Russia found themselves united against a common enemy. This unanimity in Russia at the beginning of the war resulted in the early successes which accompanied the great drive. But the Russian nation was not really united. The autocratic Russian rulers thought they were fighting a rival power; the democracy of Russia — the common people — with less reasoning but with deeper instinct, realized that they were fighting autocracy itself, — that the Great War was not fundamentally a war of national supremacy, but a war for human freedom. After a time the Russian autocrats, who controlled the government, began to realize this, and they realized also that a Russian victory meant a bureaucratic defeat, while a German victory meant the continuance of their own autocratic power. What did they do? They deliberately wrecked their own nation. Aided by the Germans in Russia, they throttled their own army, they withheld supplies and ammunition, they sent men to the fighting lines without guns, they mobilized enormous numbers of men whom they could not equip, withdrawing them from industry, but failing to make them into soldiers; they dis-

organized the railways; they made laws which upset business, injured the credit of the nation, and made food riots inevitable. They betrayed their country in a more wholesale way than ever was a country betrayed before. Had they remained in power it is thought they would have concluded an independent peace with Germany, betraying their allies as well as their own people.

Fortunately the same spiritual uplift which rose in France, the stand which was taken by England at Germany's violation of Belgium, occurred also in Russia among the true Russian people. The so-called liberals, who were, as a matter of fact, relatively conservative, stood amazed at the betrayal of their country by those they had been supporting. Thus there occurred leveling and unifying changes which brought the Russian people against their rulers, and the result was the bloodless revolution, the overthrow of Tsarism, and the establishment of the present Russian democracy. At last the true Russian people had exerted themselves; they were trying to govern themselves; they were trying to drive out the German influence; they were trying to create a new and better Russia, and they were trying to do this under the greatest handicap that can befall a nation, — they were trying to do all these things with their country still at war.

The people of the allied countries are disturbed by the failure of Russia to carry on offensive operations against the enemy. It is a natural feeling, for the enormous Russian army lies to-day relatively inactive. Some say, "Oh, that the Russian revolution had waited until after the war!" If the revolution had not occurred, the war would have been already over, so far as Russia is concerned; England and France would have lost their ally, and America would have shouldered a far greater burden than she is now called upon to bear. Autocratic Russia was not a natural ally for the free nations of France, England and America; democratic Russia is their natural ally, and, unless underhand Germanic influences in Russia succeed, — and they are straining every nerve to succeed by fair means and foul, — democratic Russia will stand firm with the allied cause.*

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* The underhand Germanic influences have recently succeeded in obtaining what I believe to be a temporary control of the government. — G. C. W.

The Russian Revolution.

There have been many attempted revolutions in Russia, but never until now were the conditions ripe for success. The foundations for a real democracy were laid in 1864, when the first Zempsvos, or local boards of government for provinces and districts, were established under Alexander II, who had also liberated the serfs. These Zempsvos undertook many important works, social and educational, and brought to the front men of public spirit. During the Russo-Japanese war, in 1905, the Zempsvos did much in the way of relief work, and their success had been such that in 1914 there was organized an All-Russian Zempsvo Union under the leadership of Prince George E. Lvoff. There was also organized a Union of Towns which joined with the Zempsvos. Moscow was the center of both of these movements; in fact, most that is truly Russian to-day centers in Moscow, the old historic capital of the nation, — center of its religion, its art, its commerce. Organized especially for war relief work in the interior, the insufficiencies of the old government made it necessary to carry on work at the front and to undertake so-called war industries, even the manufacture of ammunitions. It happened, therefore, that the united social forces of Russia became a powerful support of the war. Along with this, and in part caused by it, went a democratization of the army. Thus was the stage set for the revolution.

Then came the rascalities of the disgusting Rasputin, the intrigues of the Germanized bureaucracy, the muzzling of the press, the ban on the national assemblies, the retirement of the foreign minister Sazonoff (friend of the Allies), the treacheries of Sturmer and Protopopov, the deliberate demoralization of the commerce and the food supply, and the scandals of the army management. It became evident even to the members of the Fourth Duma, notoriously conservative, that the Russian nation was being betrayed to the enemy, and they united with the radicals and socialists in condemning the government. It was in November, 1916, when things began to move. Germany's peace terms were refused by the Duma on December 19. On December 30 Rasputin was murdered. In February, 1917, great confusion was caused by changes in the ministry. In February,

Protopopov tried to stimulate strikes so as to give him opportunity to use stern measures of repression, but he failed to appreciate the strength of his operation. A council of workmen was organized, and the soldiers joined with them. On March 10 the Tsar dissolved the Duma, but the Duma refused to disband. The next day there was a revolt in the army. Then the revolution broke. The people and the soldiers overpowered the police, opened the prisons, burned the police records, broke open the famous Peter and Paul prison, the Bastile of Russia, and seized the reins of government. By March 15 the Tsar had signed his abdication and a provisional government under the premiership of Prince Lvoff had been chosen by the Duma with the agreement of the workmen and soldiers deputies, the head of the Zempsvo Union, and with Paul Miliukoff, of the Constitutional Democrats, and Alexander Kerensky, of the Socialist party, as prominent members. The most amazing thing about the whole revolution was the small amount of bloodshed. It is true that people were killed in Petrograd, that machine guns swept the streets, that the buildings were burned, — the window of my room in the hotel had been pierced by a bullet, — but the damage, the confusion, the excitement, was largely confined to Petrograd.

And what have the Russian people done with their newly found liberty? They have done just what one might expect. At first they abused it in ways that seem childish. Each man wanted to be free. He said, Why should I work? I am free. Why should I pay for things? I am free. What need have we for police, are we not free? Why should we soldiers obey our officers? We are free; we will appoint committees in our regiments, and these committees will decide what we shall do. Why should we privates salute our officers? We are as good as they. Why should we waiters humiliate ourselves by taking tips from those we serve? We are as good as they. In many ways the Russians have acted as schoolchildren who have escaped from their teacher. They have done little, almost nothing, that is vicious; they have done much that is foolish, much that they will some day regret, and much that they will soon stop doing.

On the other hand, it is not surprising that, having dreamed

of freedom and struggled for freedom for generations, the actual coming of freedom should engross the thought of all the people, including the men in the army. "Now we will have education and be no longer the dark people; now we will have plenty instead of famine; now we will have land to own and cultivate." These are the thoughts which are uppermost in their minds, and it is all very natural.

Those who see these conditions of disorganization at the present time, with the country in a state of anarchy, before a constitution has been adopted, and are disturbed by them, should go back and read the history of the United States during what John Fiske called the critical period of its history, and the history of France during and after her revolution. Of course the lack of offensive military operations is greatly disappointing to the Allies, but when we think of what so nearly happened, or how, if it had not been for the revolution, we might have had Russia as an enemy, and not the friendly ally which she will undoubtedly continue to be, there is reason in America for great rejoicing that the revolution occurred.

Of course the divergent parties which united to overthrow the rule of the Tsar and the Germanized bureaucracy did not at once agree. After choosing the provisional government the Duma legislated itself out of existence, and since then all changes in the cabinet have been by agreement of the parties. There was no real authority for the government which we found in Petrograd. It was expected that a constitutional convention would convene in December, and that there would be an election of delegates, but the present uprising of the Bolsheviki may prevent this.

It is too early to write an account of the recent events in Russia. How far the Germanic influence has permeated the country, cannot be said at present. The present conditions are serious but not hopeless.

Work of the Mission.

We were greeted in Petrograd with no *éclat*. There were no official receptions. Many of the formalities vanished with the empire. We entered the most democratic democracy in

the world, and beside that, the only men worth seeing were so busy that there was no time for an exchange of mere courtesies. Our mission was to offer encouragement and Red Cross aid to the Russian nation in its prosecution of the war. The Root mission had already carried the greetings of the oldest to the newest of the republics. Our message was one from the people of America to the people of Russia.

The first moves were wisely made, and therein lay the secret of such success as we have had. On the day following our arrival, Colonel Billings, Colonel Thompson and Ambassador Francis called officially upon Kerensky, the head of the Provisional Government, and several members of the cabinet — then only four days old. The new surgeon-general of the army, Dr. Yuriavich, two weeks in office, was the natural head of the work in which we were interested, and he proved to be not only sympathetic but broadminded and efficient. A bacteriologist by training, he fully appreciated the nature of the help which we were able to offer. Through him, access was given to the various departments of the medical and sanitary service, to the hospitals, supply houses and the bureau of statistics. The officials in charge of these departments were found to be very able scientific men, and delightful acquaintances. Dr. Vreden, the great army surgeon; Dr. Novasselsky, the statistician; Professor Vladimiroff and his assistant Dr. Tarmox, were most cordial and helpful.

The mayor of Petrograd was called upon, and arrangements made by which the members of the Mission were brought in touch with the local health and relief work, the city hospitals, the water works, the bacteriological laboratories, the municipal markets, the bread distribution, and all of the many functions of the local Dumas. Dr. Bogorovitsky, Dr. Haffkine, Dr. Yakowleff, Dr. Stepanoff, Dr. Gamaleia, Dr. Mandelburg, were especially attentive and interested in our work.

The Russian Red Cross alone courted our attention. A meeting was arranged between the full membership of our Mission and the officers of the Society, and plans were made for complete inspection of the great work which is being carried on by them. The President, General Prokrovsky, and the chair-

man of the Committee on Depots and Supplies, General Ordin, deserve especial thanks for their courtesies.

The officials of the Zempsvo Union and the Union of Towns were visited in Moscow, and the local officials of Moscow were seen and the local relief and hospital work studied. Arrangements were made with General Korniloff, the generalissimo of the army, for us to visit the hospitals and inspect the sanitary work at the West Front.

It was found that many private agencies were at work, and that much welfare work was being done. Little by little the people in charge of these works were brought together. Calls were made upon many important persons not now holding official positions, such as Dr. Paul Miliukoff, the former minister of Foreign Affairs; the aged Prince Kropotkin and his active and public-spirited daughter, Madame Polisova; Lady Panine, and, of course, the world-famous grandmother of the Revolution, Madame Breshkofsky. The ambassadors of the Allied countries were called upon, and cordial relations established.

To all of these people, from the lowest to the highest, the story was the same. "We have come, not to any one organization in Russia, but to the Russian people; we have come not to sell supplies, not to give charity, but to find what you need and give it as a free gift of the American people; we recognize the great work you are already doing, but we are now your ally, and we have come to work with you throughout the war." It took some time for this message to be appreciated. Our first week in Petrograd was a lonesome one, but before we left the hours of the day were not long enough for the many interviews which took place. The Mission sought no newspaper publicity. It did seek, and actually secured, the cordial coöperation of the people who are at present in charge of the kinds of work in which we were most interested. In some directions we found our progress blocked, and in one field we were disappointed in not being able to accomplish more, namely, in the food supply of Petrograd. There we had to limit our activities to food for the infants. While we were there in Petrograd, we learned that the Stevens Commission, working on the transportation, had succeeded in getting authority to go ahead with their work, for

which they had been obliged to wait six weeks, and that Mr. Harte, of the International Y. M. C. A., had been given authority to go ahead with his work in the army. This Y. M. C. A. work in Russia is being actively pushed. A hundred or more American young men are on the way to Russia.

We arrived in Russia, therefore, at a time when the relations with America were becoming actively cordial and sympathetic.

No account of our work would be complete without mention of the great help of Prof. Samuel Harper, of the University of Chicago. His wide acquaintance with the Russian people and his knowledge of the language made him an invaluable interpreter and guide.

Inspection.

To tell of the many inspections of the hospitals, storehouses, workshops, laboratories and relief stations of various kinds, would be tedious, but they were invaluable in giving us an adequate picture of the work which has been and is being done by the Russians. It is wide of the mark to say that little has been done in the present war. The amount of work which has been done by the Russian Red Cross, by the Zempsvo Union, the Union of Towns and by the government itself, has been stupendous. Four million sick and wounded soldiers have been treated, two million seven hundred thousand of these passed through the hospitals in Moscow; thousands of hospitals, with an aggregate of over half a million beds, have been maintained; forty thousand first-aid packages a day were being turned out at the government shops; fifty million yards of gauze are on hand in the Red Cross stores; half a million hides were collected at the front and tanned. These figures serve to show the scale on which the work has been done.

The Russian scientists are splendidly educated, skillful and resourceful men. Some of them are splendid organizers. They do not need to be advised how to do things. In more ways than one we learned from them, rather than they from us. Nor are the Russian *Intelligencia* lacking in the spirit to do things. They have been handicapped by their badly organized government, by the deep-seated and far-reaching evils of graft among officials, and by an inertia born of these things.

Our inspections and interviews showed us that what the Russian scientists and officials need is not advice, but sympathy and encouragement; not an assumption of certain work by American men and women, but cordial coöperation, with here and there, in many places, help in obtaining the supplies which they cannot otherwise secure and which in some cases they very greatly need.

Distribution of Supplies.

Our two carloads of supplies, hastily gathered together in a week's time and having a value in Russia of perhaps a quarter of a million dollars, included medicines, surgical supplies, microscopes and laboratory apparatus, antitoxins and vaccines.

These were housed in the storehouse of the sanitary department of the Russian army, this being under the authority which best represented the Russian people. After consultation and inspection of the needs, many of these supplies were distributed soon after our arrival. It was this free gift of supplies so greatly needed which touched the hearts of the Russians and gave them confidence in the message which we had brought from America. It was a spirit new to them, a spirit which they had not associated with America. On several occasions when we showed our lists of supplies and asked which of them they needed, the officials said, "We need these and these; now what do they cost?" The answer was always, "Show us that you need them, and they are yours as a free gift from America." On one occasion when this was told to an old physician in Moscow, his eyes filled with tears.

Of course the supplies which we carried did not anticipate every want, and of course many more supplies will be needed. It has been arranged, however, to send supplies at regular intervals. Russia needs many things besides those supplies which it would be within the province of the American Red Cross to send. She needs money, but she also needs shoes, and clothing; she needs manufactured articles of many kinds, tools, machinery, engines and automobiles; she needs all sorts of merchandise which the peasants can use or buy. With no supplies to purchase, no vodka to buy, with the rouble depreciated in value,

the peasants prefer to hold their grain, preferring it to money, and this is one reason why food is scarce in the big cities. The big cities have nothing to give in return. Russia as a whole has food enough for the present. The stimulus for distribution and the means of distribution must be provided.

Organization.

The first work of the Mission was to deliver the message, the second to organize the work. The third will come later, — to furnish the supplies at regular intervals and carry on the coöperative work.

When we arrived at Russia we found that, while the four most important organizations engaged in medical work, namely, the Sanitary Department of the Army, the Zempsvo Union, the Union of Towns, and the Russian Red Cross, were working harmoniously at the front and doing work along parallel lines, there would be difficulty in properly distributing American supplies unless these organizations could be brought closer together. The Red Cross had received its support largely from the old régime, the Empress herself having been one of the strong supporters and the Winter Palace having been turned into a Red Cross hospital. The headquarters of the Red Cross was at Petrograd. The Zempsvo Union, on the other hand, received its support from the local communities throughout the country, the headquarters being at Moscow. Since the revolution, all of these organizations have received support from the government. After several weeks of interviews, these organizations finally joined together in establishing a joint committee, and hereafter the American Red Cross will have a stable body with which to transact business, one which will insure a proper distribution of the supplies furnished.

When Colonel Billings, with most of the specialists of the Mission, returned to America, seventeen men were left in Russia, this number being raised to about twenty by additional appointments. An office has been opened in Petrograd, and storehouses will be established.

Discouraging Features of the Situation.

The question in which America is immediately interested is, What is the Russian army going to do in the war? There are perhaps ten million men mobilized, but less than that are actually under arms and equipped for work at the front. Whatever the number may be, it is an enormous force; in fact, it is too large. To offset this, however, is the present disorganized condition of the army, due to its so-called democratization. The substitution of committee rule in regiments for the stern military discipline, the abolition of the death penalty, the lack of coördination of the work of the different armies, the uncertainty of the standing of the officers and their fear lest their actions may not be supported by the changing war ministers, the war weariness of the soldiers themselves, their interest in the new freedom, and especially the insidious influences of German propaganda have united in producing a condition which makes vigorous offensive operations unlikely if not impossible. The railways, governmentally operated, are disorganized; the military roads are bad; the sanitation at the front extremely unsatisfactory, and the amount of sickness great. These conditions are indeed disappointing. Yet, in spite of them, when we were there, the men in the trenches were still fighting, and the attacks of the Germans were being followed by counter-attacks of the Russians. As long as this sort of fighting is kept up, the Germans cannot withdraw troops from the Russian border to use elsewhere. Even though the Russian retreat here and there, if they hold their thousand miles of continuous trenches from the Baltic to the Black Sea there is no reason for the Allies of Russia to be discouraged. Furthermore, it appeared to us that already the nation was beginning to realize the necessity of stricter rule, of greater discipline. "We need discipline," some say, "but we want democratic discipline." Russia has lost Riga, she may lose Petrograd; but even with these losses Russia would still be Russia, and we heard the opinion expressed not infrequently that if Russia were compressed it would be to her ultimate advantage, as such compression would surely bring into action a counter force of great violence.

Looking ahead, too, there are things to be viewed with

apprehension. Official Russia has been honeycombed with graft. Not only government officers, but railway officials, even station agents and train conductors, have not hesitated to take their percentage from the unprotected public. The abolition of tips and other perquisites since the revolution is said to be having its effect, and one of our American consuls told me that he saw in this an important step towards the abolition of graft in high places.

The land question, however, is the great problem in Russia. Without doubt the great holdings of land by the state, the church, and wealthy individuals is wrong in principle. These great land holdings ought to be subdivided and ownership distributed. It is here where parties differ. Some would seize the land without compensation to the owners, some would take the land but pay for it in full, some would pay a part. Others want a complete socialistic control of the land. It may be years before this question is satisfactorily settled.

The greatest and hardest problem at present is that of meeting the German propaganda both in Russia and America. The mobilization of too many men made Petrograd a nest of loafing soldiers and furnished a rich soil in which to sow sedition. The German propagandists invaded the army, and said, "Go home and get the land which is being distributed." "You have succeeded in your revolution; soon there will be a revolution in Germany, so give up your fighting." "The American capitalists are now coming into the war for their gain and your loss." In America there is a steady attempt made to discredit Russia in our eyes. Unconsciously, perhaps, the press has encouraged a spirit of pessimism and resentment in regard to Russia and the Russians, undeserved by them and unwarranted on our part. Truthful news fails to travel in either direction. We do not get the facts straight from Petrograd; the Russians do not hear what we are doing. Relatively few in Russia understand the spirit with which America entered the war or the vigor and determination with which we are proceeding. The need of the hour is for America to speak loudly to Russia and give her words not of abuse but of encouragement, and to read the daily dispatches from Russia critically and sympathetically.

Grounds for Optimism.

The outlook on the surface is highly discouraging, but a nearer and deeper look tends to make one take courage. It tends to make one appreciate what has already been done, and to feel that the situation is by no means hopeless.

I believe in Russia and have faith in the nation for the following reasons:

The real Russians, who are in the majority in the central part of the nation, and are also found scattered through the country, are sturdy, hard working, patient, kind hearted, courageous and likable. Illiterate, to be sure, but they have a longing for education. It is going too far to say they are ignorant. They have an idealistic and sentimental streak, but when given opportunity they become good thinkers, the best of mechanicians, and in general substantial citizens.

There are in Russia not only great artists and musicians, but able scientists and able, patriotic leaders. We saw and talked with many of these men, and came to admire them. They are the men who will soon control the nation.

The Zempsvos, or local governing organizations, which have been in existence for fifty years, have built up a substantial governmental fabric capable of furnishing the basis of the new democracy.

The Russian Church has been democratized. Once the most autocratic of all churches, it has been completely changed since the revolution. It has been not only liberalized, severed from national political control, but purified. When one realizes the tremendous influence which the church has over this naturally religious people, it may be rightly argued that its influence for democracy and for law and order will do much to stabilize the nation.

The Russians have thrown out the Germanized upper class, — the Romanoffs and their satellite bureaucrats; they are now engaged in a struggle with the Germanized lower class, the extreme radical socialists, the Bolsheviki and Maximalists, a class which though noisy and treacherous is really a small minority, and confined chiefly to the large cities, especially Petrograd. With this Germanized element eliminated, reorganization of the

government will make visible progress. Petrograd is no more Russia than New York or Boston is America. Moscow is the center of the real Russian nation.

The resources of Russia are very great. With these resources the country should be able to pay its just international obligations.

The Russians subscribed generously to their own liberty bonds, and "Where your treasure is, there will your heart be also."

The Russians have suffered enormously in this war. They are not likely to give up that which has already cost them so dear.

The nation has abolished vodka, and I believe that Russia sober means a Russia saved.

Russia after the War.

No nation can build up a stable government in a year, and with a nation like Russia, with a population of 185 million people, with an area of 8 600 000 sq. miles, with three quarters of the people illiterate, it will take many years for affairs to become really settled. The war will end before Russia becomes really stabilized. Then will come the great problem, and one in which America — and especially American engineers — will be vitally interested. Can Russia become organized commercially and financially so as to develop as she ought without external aid? Those who have studied the situation say "No." After the war, then, whose and what influence shall be of greatest benefit to Russia? That Germany hopes to control the country for German gain is obvious. She has been trying to do so for a hundred years. I believe that in this she will not succeed, unless she too becomes a liberal nation. The feeling against the Germans among the real Russians is too strong. Autocratic Germany has overreached and lost. Liberal Russia will not tolerate an autocratic Germany.

Shall Japan be the outside power to influence Russia? She, like Germany, is near at hand; she has interests in eastern Asia which closely touch those of Russia. Manchuria is a debatable

country, in which Russia, Japan and China are all interested. Japan is rapidly developing the instinct of organization which Russia needs. Shall Japan be the nation to help Russia organize? Admirer, as I am, of the self-improvement of the Japanese, of their wonderful capacity for organization, I do not believe that it would be for the interest of Russia or of the world's peace that Japan should do this. I do not believe that at present Japan could help Russia with unselfish motives.

There remains England and America, and especially America. England is already helping Russia. There is already an Anglo-Russian Commission planning to carry on various educational and commercial enterprises intended to bring the Russians and the Anglo-Saxons closer together. But it will be difficult even for England to be entirely unselfish in giving this help. Of all the nations on the earth, America can help Russia most.

Our past relations have been friendly, our mutual interest in democracy is strong, and national traits are not unlike; we have no adjacent frontiers to cause difficulties between us; we can have no possible conflicts as to territory, but we can give what Russia needs and Russia needs what we can give, — sympathy, moral and political support, educational help, financial capital, commercial dealings, trade.

Russia must build herself up by the slow process of education and self-improvement. With the fetters of a crushing autocracy removed, the natural ability of the Russian people will exert itself and Russia will become one of the great centers of civilization. What Russia can be is well shown by that small part of her population known as the *Intelligencia*. There are no better scholars, no finer gentlemen, in the world than are to be found in Moscow. We have already come to appreciate Russian music, Russian literature, and Russian science, but in our ignorance we have looked askance at the common people of Russia. We need to learn that their faults are our faults, that they have a great capacity for self-improvement, and that except as climatic and geographical conditions hold them in check they are bound to forge ahead and play a notable part in the world's future.

America's Opportunity.

Looking ahead, we see in this great land a wonderful opportunity for America and American engineers to aid in the development of natural resources and the advancement of civilization of the world. The journey back and forth across Siberia cannot fail to be a revelation and an inspiration to any American who has constructive imagination. The vacant plains have a soil rich enough to supply grain for the world; the virgin forests of splendid timber cover tens of thousands of square miles; the mineral resources are almost untouched. Siberia, once regarded as a land of exiles, will some day become filled with prosperous farmers; cities will spring up on the great rivers; there will be railroads and water power and manufacturing; and there will be schools and universities, and all that makes for a high civilization. Even in European Russia there are great natural resources undeveloped, fertile land, and coal and oil and mineral wealth. Nowhere in the world will there be greater opportunities for the young men of America than in Russia.

At the present time, the young men of America do not know Russia. During the last few years their eyes have been turned towards South America, and they have taken to the study of Spanish as a preparation for future commercial enterprises. In the same way they should prepare themselves for commercial enterprises in Russia by the study of the Russian language. It is true that this language is more difficult to an American youth than is Spanish, and the college men of America are not prone to choose a difficult subject when there are easier ones to be had; but, if the difficulties in Russian intercourse are greater, the prizes are also greater.

In order that America may help Russia in the right way, our universities should strengthen their Slavic departments. Students should be encouraged to study the Russian language. Russia should be studied not only for its literature and its history, but for its economic possibilities. I should like to see a well-endowed chair of Russian economics in Harvard University. Such a chair would greatly stimulate the study of the Russian language. There should be an interchange of university professors between America and Russia. Provision should be made by the Russian government for scholarships to be given to the

young men and women of Russia in American colleges. There is also much for American students to learn in Russia.

Russia needs practical, technical education. In her existing Germanized universities and technical schools, theory is carried to absurd limits, the applied sciences are neglected, the laboratory method of instruction is not used. England and America should immediately take up this problem of technical education in Russia. Good text-books on technical subjects are lacking. These must be supplied by us. Many of our text-books might well be translated into Russian. Russian students are ignorant of American progress. We should arrange to have more daily news, more magazines, more technical journals and reports scattered through the country. Russia needs laboratories of all kinds, — chemical, mechanical, electrical, mining. Russia needs better medical courses. Sanitation in Russia is at a low ebb. Few cities have public water supplies and sewers. Most of all, perhaps, Russia will need teachers for her elementary and secondary schools. It may be necessary for America to help in this field also.

The present physical needs of Russia are likewise great. She needs tools of all kinds, especially farming tools, and factories for making tools; she needs the basic industries of steel making, steel working; she needs locomotives, cars and equipment for her railways; she needs the chemical industries; she needs manufactured articles of all kinds, boots and shoes, clothing.

Russia needs capital and financial assistance. She must have outside aid to develop her natural resources.

All these things America can give. But America must not do as Germany has done. German development always placed Germany first. America must place Russia, not America, first. Reasonable profits in Russian investments can and ought to be expected. With a liberal Russia and a stable government, Russian investments will be safe. Between Russia and America there is ample opportunity for profitable trade, profitable on both sides; ample opportunity for unselfish and rewarding service in many directions; ample opportunity for America to give the world a demonstration of that international good-will which must be the safeguard of the world against a repetition of the present awful war.

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PAPERS AND DISCUSSIONS

WATER POWERS OF NEW ENGLAND.

By Henry I. Harriman.*

(Presented October 17, 1917.)

Conservation and efficiency are the passwords of the twentieth century. Conservation deals with the creation of effort, efficiency with its application; and together they symbolize the fundamental philosophy of our time, namely, that all energy and effort should be created in the most economical way, and applied in the most useful manner. Efficiency and conservation deal with all classes and kinds of human and mechanical effort, but they are particularly associated with the generation and application of power, and in this special field the use of electricity has become almost synonymous with efficiency; and its generation by water has, at least in the popular mind, become associated with conservation. It is therefore particularly fitting that we should briefly consider the utility and value of our very great water-power resources.

The use of water power in New England dates back to its very earliest history. John Alden owned and operated a water mill near Plymouth, and near Little Compton, R. I., can still

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Note. Discussion of this paper is invited, to be received by W. L. Butcher, Editor, 14 Beacon Street, Boston, before February 10, 1918, for publication in a subsequent number of the Journal.

be seen the old Peregrine White mill, owned by and named after the first white child born in New England.

Our forefathers in coming to this country were dependent upon their own efforts to raise their own food and build their own shelter, and among the first necessities of life that confronted them was the ability to grind their corn and wheat into flour, and to saw the timber from which to make their homes.

They were familiar with the gristmills and the sawmills of England, and well understood the construction and operation of primitive dams and water wheels, and the use of the energy of falling water. It was therefore natural that our streams should have been put to useful labor in the very earliest Colonial days.

So vitally necessary to the life of the community did these water mills become that, within seventy-five years after the landing of the Pilgrims at Plymouth, two of the colonies had evolved the principle of the Mill Act, — a principle entirely unknown to the common law of England, — which gave to the owner of a dam-site the right to flow out the land of his neighbor in order that water power might be created.

With this limited right of eminent domain thus early created, there also went a limited duty of public service, and in early Colonial times definite rates were sometimes established by law for the grinding of grain and the sawing of logs. The establishment by law of definite rates was, however, unusual, and more frequently the water mill was coöperatively owned and operated by the largest timber owners of the district. The opportunities for the development of power were, however, so many, and coöperatively owned mills so numerous, that all vestige of public regulation ceased long before the outbreak of the American Revolution.

The doctrine of the English common law, that the riparian owner on a non-navigable stream owned the bed of the river to the center of the stream, has always been accepted in our New England states, as has also been the right of the owner to construct dams upon his land, this right being subordinate, however, to the right of all owners along a water course to have the water flow by in a reasonably uninterrupted manner, and to the rights of the public to float logs and to exercise certain other public privileges.

The invention of the cotton gin, the loom and the spinning jenny ushered in a new era in manufacturing, and greatly increased the demand for mechanical energy, and whereas, up to the beginning of the nineteenth century, the use of water power has been very largely limited to the making of flour and lumber, with the advent of the new century there was witnessed a very great increase in the development of our streams for the operation of cotton and woolen mills, and associated industries. The process of manufacturing paper from ground wood was also discovered and developed, and a large amount of power so utilized. It is true that the steam engine had been invented, coincidentally with the other great inventions that signaled the close of the eighteenth century, but it was still a new and crude mechanism, and its use very limited. In fact, it is fair to say that up to 1850 ninety per cent. of the power required by our industries was derived from the energy generated by falling water.

New England has always been prominent as a center for all kinds of manufacturing. Her rugged coasts and barren hills, and the relatively poor soil, did not lead to such extensive development of agriculture as took place in our middle and southern states; and her trend was naturally toward the manipulation rather than the growing of the raw products which could better be raised elsewhere. Hence there sprang up, around her more important and accessible water falls, great manufacturing centers, such as Lowell, Lawrence, Lewiston, Manchester, Holyoke and many other and smaller towns.

It was not then possible to carry power any material distance from the site of the fall. The industry must go to the water power and not the water power to the industry. In fact, there is hardly a single manufácturing city of any size in New England whose origin cannot be traced back to the development of some waterfall within its limits. Manufacturing was started in New England long before coal was used, before the locomotive was thought of, and almost before the steam engine was invented; and the use of water power was universal as a source of energy until the close of the first half of the nineteenth century. Then, as manufacturing facilities increased and as the more desirable water powers were completely utilized, and as the efficiency and

reliability of the steam engine increased, our manufacturers turned from water power to steam power, preferring to locate their mills and factories on the seaboard, or in large centers of population where labor conditions were best, rather than to follow the courses of the streams back into the high hills. For nearly forty years water-power development in New England was neglected. Then with the development of the art of electric generation and transmission it became possible to bring the power to the manufacturer, and to have the double advantage of locating in the large centers of population and of utilizing cheap power generated by water.

The beginning of this century was marked by a great development of the more remote water powers of the country, and the transmission of electricity therefrom to the large centers of population. In the New England states, however, the largest and most conspicuous water powers had been developed and utilized long before the advent of electric transmission, and therefore the first great distribution systems of the country were built in the western and southern states. The Pacific Coast was a pioneer in this class of work, largely because of the scarcity and high price of coal, and the first transmission line to exceed fifty miles in length was built by the predecessor of the Pacific Gas and Electric Company, extending from the foothills of the Sierras into San Francisco. Another step in electric transmission was marked by the building of a line 150 miles long from the Kern River to Los Angeles, while the recent construction of a line to that same city spanning 250 miles marks the maximum transmission distance thus far attained. Extensive electric transmission systems have also been constructed in the southern states, the Southern Power Company having a network of between four and five hundred miles of line which link together nearly all of the larger manufacturing centers of North and South Carolina.

While it is true that many of the large water powers near the greatest centers of population in the New England states were developed long before the advent of electricity, it is still true that few sections of the country offer greater opportunities for hydroelectric development and transmission than our own New England states.

An interesting computation has been made as to the theoretical amount of energy which might under ideal conditions be generated by water. On the assumption that the average run-off in New England is 18 ins., that its area is approximately 60 000 square miles, and that its average elevation above sea level is 900 ft., it is computed that it would be theoretically possible to develop, for three thousand hours of each year, 15 500 000 horse-power, this being equivalent to the use of 52 000 000 tons of coal annually. Of course such a computation is nothing but an interesting mathematical calculation. It is, however, entirely possible that ten per cent. of this theoretical power may some time be developed from its streams, and that New England may be able to produce energy equivalent to that which can be produced from 5 000 000 tons of coal.

In the New England states there are eight large rivers with very great fall, namely, —

The Penobscot, with a total fall of	1 500 ft.
The Kennebec, with a total fall of	1 000 ft.
The Androscoggin, with a total fall of	2 200 ft.
The St. Croix, with a total fall of	400 ft.
The Saco, with a total fall of	1 900 ft.
The Merrimac, with a total fall of	269 ft.
The Connecticut, with a total fall of	2 000 ft. and
The Housatonic, with a total fall of	900 ft.

These rivers drain 35 000 out of the 60 000 square miles of New England, and, because of their great watershed and large drop, are its greatest sources of present and future power. Along these rivers are found our greatest water-power developments and our greatest manufacturing centers.

An estimate has also been made by the Bureau of Corporations, showing that in the six New England states there is now developed and in use over 600 000 horse-power of water energy, but that these same water-powers if properly reconstructed along modern scientific lines could generate an additional 200 000 horse-power. The same report shows that there is possible of creation in the New England states a minimum water-power development of 1 000 000 horse-power, which, by storage and by the utiliza-

tion of some of the less desirable powers, can be ultimately increased to 2 000 000 horse-power. The state of Maine leads, both in developed and undeveloped water-power, having a maximum possible development of nearly 1 000 000 horse-power; the power of New Hampshire, Vermont and Massachusetts is reckoned between 200 000 and 300 000 horse-power each; Connecticut has 160 000 horse-power, and Rhode Island ends the list with a possible 16 000 horse-power.

There is little doubt that New England can absorb all of the water-power which can be developed within its limits, for it is one of the greatest and certainly the most diversified centers of manufacturing in our country. The Census Department gives the total value of all the manufactured products of the United States at $20 000 000 000 per year, and the six states east of the Hudson, with approximately 2 per cent. of the area of the country and about 4 per cent. of its population, produce over 10 per cent. of this great total. The boots and shoes manufactured in New England are valued at approximately $300 000-000; its cotton mill products are worth an equal amount; its woolen mills produce goods valued at $200 000 000; and its paper mills add to this an additional $100 000 000 of product. It is also interesting to note that in no other section are there so many small manufacturing concerns. Massachusetts alone has over 8 000 separate manufacturing companies, the total in the New England states being in excess of 12 000, and while centralization in the ownership and control of industry has been most marked in our middle and western states, in New England there has been an actual increase in the number of productive concerns and a decrease in their average size.

The mechanical and engineering problems connected with the development of water power and with the transmission of electricity therefrom, to any distance up to 200 or even 250 miles, may be considered solved, and the question to be settled is now one of commercial feasibility. The generating of electricity may properly be considered a form of manufacturing, water being the raw product, and electricity the resultant; but it differs from ordinary manufacturing in two important essentials. First, electricity cannot, to any material degree, be stored

or kept for future use. It must be used when and as it is manufactured. In the second place, it can only be transported over wires reserved for its particular service, and its market is therefore limited to the industries which are located within reasonable transmission distance. Conceive, if you can, the difficulties which would face the manufacturer of woolen cloth who must manufacture his goods and deliver them on the same day, who must use his own trucks for the delivery of his own cloth, being denied the use of railroads and other means of transportation, and whose only market lay within a radius of 200 miles of his plant; and yet such is the problem that faces the manufacturer of electricity.

While great difficulties confront the manufacturer and seller of electricity generated from either water or coal, yet few lines of industry offer greater opportunities if wisely and conservatively managed. Of all the forms of power, electricity is the most transportable, and within reasonable limits can be cheaply carried from the place of generation to the place of use. Again, electricity is the most transmutable of all known forms of energy. It can be easily transmuted to the form of light; it can be changed into the form of the most intense heat for use in the electric furnace; it can be applied to the locomotive to give tractive power; it can be changed into mechanical energy for the turning of the wheels of industry. In fact, no other form of energy can be so easily transmitted from place to place, or so easily applied to useful work.

Despite the wonderful growth in the generation and use of electricity within the last decade, it is still fair to say that the electrical industry is in its infancy. For instance, it has been demonstrated that in many cities carting and teaming can be more cheaply done by the electric truck than by the horse-drawn vehicle, and it is estimated that, if the horse-drawn teaming of New York City were to be done by the electric truck, the amount of electricity required would exceed twice the present output of the New York Edison Company.

Electricity as applied to railway transportation is just beginning to prove its reliability and its feasibility. Already seventy-five miles of the New Haven Railroad, passing through

one of the most densely settled sections of the country, is operated by electric locomotives, and the St. Paul road is electrifying over four hundred miles of its road west of Butte, Mont. Wherever railroads have been electrified, much benefit has resulted, both to the corporation and to the public. It has been possible to give a more frequent train service without added cost; there has been great saving in coal, and even a greater saving in maintenance and upkeep; the strain upon the roadbed is less serious; the smoke nuisance is eliminated, and loss from fires set by locomotive sparks has entirely ceased. These advantages are so important there is little doubt that a very great amount of railroad electrification will take place as soon as financial conditions warrant.

The great extent to which electricity is being used for electrochemical purposes is hardly appreciated, yet two thirds of the energy generated by all of the companies at Niagara Falls is now so utilized. In fact, the number of kilowatt hours consumed in the electric furnace to-day exceeds that generated for light and power in the five largest cities of the country, and yet the possibilities of this industry are but faintly appreciated, and we smile at the prophecy of the scientists that the fertility of the earth will be maintained by the nitrogen abstracted from the air by means of the electric arc.

The manufacturer of electricity can also to a very great degree claim exemption from the serious labor problems which face so many other forms of industry. A modern hydroelectric plant with its distribution system does not spend more than ten per cent. of its gross income in the employment of labor, whereas the railroad and the trolley must so expend about fifty per cent. of its gross receipts, and many manufacturing industries must pay out seventy-five per cent. of their gross income for human effort.

In a comparison of the operating costs of a steam and a hydroelectric plant, the ultimate effect of the sinking fund upon the cost of power is not fully appreciated. No one would question the great advantage of the hydroelectric plant over the steam plant if the former could be had without cost, that is, without capital outlay; if its cost were $50 per kilowatt, its

advantage would still be unquestioned; at $150 its value might be debatable, and at $1 000 every one would condemn it. In fact, the relation between the water-power and the steam plant is almost entirely dependent upon capital cost of the former.

If it is assumed that each kilowatt of machinery in a hydroelectric plant (costing approximately $150) produces 4 000 kilowatt hours per year, and if it is further assumed that one mill per kilowatt hour is put into a sinking fund and reinvested in the six per cent. securities of the company, the fund thus created will have reduced the cost of the plant from $150 to $100 per kilowatt at the end of the tenth year; at the end of the sixteenth year its cost will have been lowered to $50, and by the end of the twentieth year the plant will have been entirely paid for, and the company owning it will be in the very desirable position of being able to operate a hydroelectric plant without capital charge, and with very slight running expenses.

The economy of generating and distributing electricity in great quantities is now so apparent that no time need be given to its demonstration, and while it is true there are certain industries which require such large amounts of steam for industrial purposes that the central station can never hope to serve them, they are in the great minority, and, of the 1 500 000 horse-power now used in New England for manufacturing purposes, at least 1 000 000 horse-power may and probably will at some time be secured by the electric company. No manufacturer who can buy electricity at a rate equal to or less than its cost if made in his own plant will desire to make expenditures for boilers and engines when that same investment in productive machinery will bring in much greater returns. The big central station is here, and it is here to stay; it will grow larger and larger, it will be located at the best place, and from it will radiate lines which will carry energy for lighting, for trolleys, and railroads, and for every other form of industry.

Assuming, then, that the great generating plant, with its network of transmission lines, will supply the energy of the future, the question is often asked as to the relative value of and the relation between the central stations which produce their energy by water and those that generate power by steam,

and this involves a consideration of the relative costs of water powers and steam stations, the ability of each kind of station to carry peaks and loads of high load factor, the requirements of the water-power for auxiliary electricity during seasons of low river flow, and the ability of the steam station to supply this need without added capital expense.

A modern and efficient steam plant of large capacity can, under normal conditions, be constructed at a cost of from \$50 to \$75 per kilowatt of installed capacity, while a hydroelectric plant will cost from \$100 to \$150. Also, the hydroelectric plant must, in many cases, be located much further from its market than the corresponding steam plant, thus adding to its relative cost. It is therefore fair to assume that the first cost of the water plant will be at least double that of the steam station. But while the cost and consequently the interest on the investment is double, the depreciation and maintenance charges (expressed in percentages) are much less, as there is practically no depreciation or upkeep for water rights, dam or power house, and water wheels and slow-speed generators depreciate less rapidly than boilers, stokers and high-speed turbines. It is probably fair to assume that, while the fixed charges — which will include interest, maintenance and depreciation — on a steam plant will be 15 per cent., the corresponding expenses in connection with a hydroelectric plant will not exceed 11 per cent. Thus, the fixed charges on a steam plant costing, say, \$65 per kilowatt will be \$9.75 per year, whereas the corresponding charges on a hydroelectric plant costing \$150 will be approximately \$16.50, the balance being \$6.75 per kilowatt per annum in favor of the steam plant. The operating expenses of the hydroelectric plant are of course very much less than the corresponding costs for the steam plant. One-half mill per kilowatt hour is a liberal allowance for a water-power plant of large size, whereas the corresponding operating charges of the large steam plant will run from 4 to 10 mills per kilowatt hour, the variation in steam cost resulting from difference in the size of the plant, its load factor, and its efficiency.

Most successful hydroelectric plants are so designed that their forebays or ponds will hold the average flow of the stream

for from twelve to twenty-four hours. It is also usual for such plants to have a very much larger capacity of machinery than is required for their average output, as additional machinery can usually be added with a proportionately small increase in outlay; and this combination of the ability to hold the daily flow of the stream and utilize it during the exact hours of the day when most required, and to have large capacity at low cost, makes it possible for the water-power plant when run in conjunction with the steam plant to take the winter peaks and the daily swings in load most cheaply and economically, it being far easier to throw on an additional water wheel than to start up extra boilers and steam turbines. Again, the steam plant is of necessity relatively inefficient during parts of the night and on Sundays, when the load is small, but when steam and water plants are run in combination, the load can be so divided between them that each plant will carry the load during the times of the day when it can be most efficiently operated. Finally, the water plant during the seasons of the year when the stream flow is large has the ability to carry an output of high-load factor at very low cost, there being no added cost for fuel because of the increase in load factor.

Most of our large New England streams vary greatly in their maximum and minimum flow. For instance, at the Vernon plant of the Connecticut River Power Company the flow varies from a minimum of 1 500 cu. ft. per second to a maximum of 150 000 cu. ft., the maximum flow being one hundred times the minimum. It would not be profitable to make such a development on the basis of the minimum run-off of the river, and in the plant in instance its primary output requires a flow of about 3 500 cu. ft. The extremely low flow of course occurs only on a relatively few days, and in an average year the plant will have sufficient water to carry its full load for nine months, the actual number of kilowatt hours required from steam being about 3 000 000 out of a total annual output of 50 000 000 kw.-hr.; that is, from five per cent. to six per cent. of its load.

It is stated on reliable authority that one half of the capacity of our central stations is idle ninety-five per cent. of the time, but whether this exact percentage is correct or not, it is certainly

true that every such station must have a very great spare capacity during much of the year; and, fortunately for both the steam and hydroelectric plants, the periods of low water occur during the summer and early fall, when the central station load is at its minimum. Thus the central station can supply the deficiencies of the hydroelectric plant without any increase in installed capacity or fixed charges, and in doing so it will increase its load factor and decrease its unit operating cost.

All of these facts lead to the conclusion that the large steam plant and the large hydroelectric station can develop side by side, each caring for the service to which it is best suited, and each giving to the other economies which neither could have alone.

Among the large hydroelectric developments in New England is the plant of the Rumford Falls Power Company on the Androscoggin River at Rumford, Me.; the plant of the Androscoggin Power Company on the same river, near Lewiston; the plants of the Cumberland County Power and Light Company on the Saco River near Portland; the plants of the Bangor Railway and Electric Company near Oldtown and Ellsworth; the plants of the Central Maine Power Company near Waterville; the plant of the Turners Falls Company on the Connecticut River at Turners Falls, Mass.; the plant of the Connecticut Power Company on the upper Housatonic; the plant of the Connecticut River Power Company on the Connecticut River near Brattleboro; and the plants of the New England Power Company on the Deerfield River. These various plants have an aggregate capacity of about 250 000 h.p. Nearly all of them have been constructed within the last five years, and indicate the rapidity with which our streams are being utilized and their energy transmitted to distant cities and towns.

Very considerable progress has also been made in the development of storage and the consequent conservation of the flood waters of the spring. A dam at the outlet to Moosehead Lake impounds a total in excess of 30 billion cu. ft., and is capable of more than doubling the minimum flow of the Kennebec River at Augusta. Storage reservoirs on the Rangeley Lakes and in the upper waters of the Androscoggin have assured a minimum flow of 2 000 sec. ft. at Rumford Falls and Lewiston,

and a reservoir created in Somerset, Vt., is now storing enough water to produce in existing plants approximately 25 000 000 kw.-hr. which would otherwise be wasted.

We have considered, thus far, the hydroelectric developments in their relation to immediate and present industrial conditions, but their development should also be considered from the broader standpoint of the conservation of human energy and the liberation of human effort. The water-powers of New England are to-day producing more than 2 billion kw.-hr. of energy, which are utilized for the operation of manufacturing plants, for the production of light, for the motive power of trolleys and railroads, and for other purposes. If this energy were produced by coal, it would mean the annual consumption of 3 million tons, worth about 15 million dollars, and to produce, handle and transport this coal would require the continuous labor of 30 000 men, working three thousand hours a year. Thus the development of our own home water-powers makes it possible for 30 000 men to turn their efforts to other channels of industry and to the production of wealth in other forms. Less than this number of men dug the Panama Canal in seven years, or in the same period could have built a double-track railroad from New York to San Francisco. Therefore there can be no doubt that the utilization of our water resources stands on a par with the great inventions and discoveries of the age. Eli Whitney invented the cotton gin, and made it possible for one man to do fifty men's work. Hargreaves, Arkwright and others invented and perfected our cotton and woolen machinery, and gave power to one weaver to produce more cotton and woolen cloth than could one hundred weavers, one hundred years ago; and likewise the great inventions in the electric industry have made it possible for one man at the switchboard of a hydroelectric plant to draw more energy from nature's storehouse than could one thousand men a century ago. And while we may discuss the relative merits of this development or that, or the advantages of the steam engine, Diesel engine or water wheels, in the long run we may feel sure that the energy of falling water will be utilized to the fullest extent and that the powers of our streams will be made to do useful work for the benefit of mankind.

MEMOIRS OF DECEASED MEMBERS.

JOSEPH PHINEAS DAVIS.*

Past President and Honorary Member Boston Society of Civil Engineers.

Died March 31, 1917.

Joseph Phineas Davis was born in Northboro, Mass., April 15, 1837, the son of William Eager and Almira L. (Sherman) Davis. All the lines of Mr. Davis's ancestry lead back to men and women who came early to New England, and many of them were active and efficient in the establishment of our institutions. On the paternal side he was descended in the seventh generation from Capt. Dolor (or Dollard) Davis and Margery Willard, who came to New England in 1634 with Mrs. Davis's brother, Major Simon Willard. On the maternal side he was descended from Capt. John Sherman, who came to America in 1634 and settled in Watertown, Mass. Captain Sherman became town clerk, selectman, representative to the General Court and ensign. He was also steward of Harvard College and a captain of the militia.

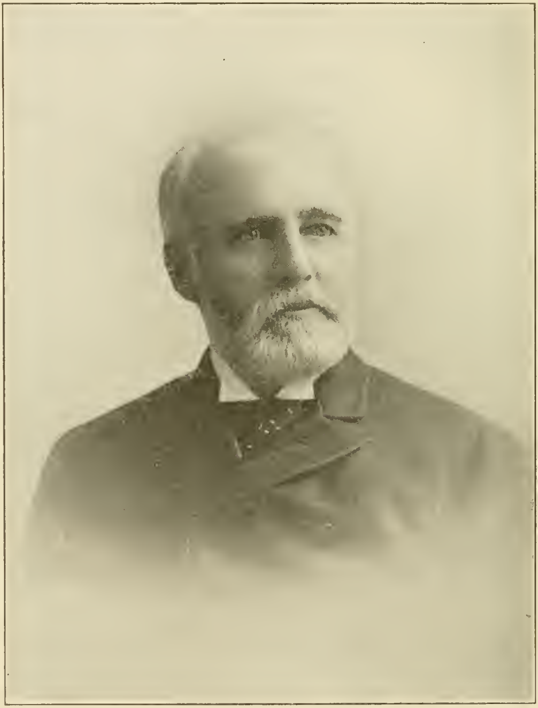
A brother of the grandfather of the subject of this memoir was the Hon. John Davis, for four years the governor of Massachusetts and for fourteen years United States Senator.

Mr. Davis's father died about four months before his son, Joseph, was born, and eight years later his mother married Israel C. Rice, of Boston. Mr. Davis never was married.

Mr. Davis was graduated from the Rensselaer Polytechnic Institute in 1856, and in the same year became assistant engineer on the construction of the Brooklyn, N. Y., Water Works, where he continued until 1861. From 1861 to 1865 he was topographical engineer for the government of Peru. In 1865 he returned

* Memoir prepared by Frederic P. Stearns and Edward W. Howe.

to the Brooklyn Water Works. In 1866 he became chief engineer of the Brooklyn Park Commission. From 1867 to 1869 he was principal assistant engineer of the St. Louis Water Works. In



JOSEPH PHINEAS DAVIS

1870 and 1871 he was chief engineer of the Lowell, Mass., Water Works. In November, 1871, he was appointed chief engineer of the Cochituate Water Board, to investigate and report on an additional water supply for Boston. After making a thorough investigation of all sources available, he recommended taking

a supply from the Sudbury River. Works for this purpose were carried out under his direction and completed in 1880, within his estimate of cost, which was approximately $5 000 000.

In 1872 the office of city engineer of Boston became vacant, and as there were differences of opinion in the city government as to the engineer to be elected to this office, the matter was referred to a commission of prominent engineers, who reported recommending the selection of Mr. Davis, and his election followed. The commission in its report, after referring to the qualifications of other candidates, said:

"Mr. Davis, in addition to a thorough special education as an engineer, has had a more varied and valuable professional experience than either of the other gentlemen. Especially in that branch of his profession which relates to the supply and distribution of water, and water work generally, does he appear to be eminently qualified. He has filled important positions upon several works of great magnitude, and of others he has had the full responsibility as chief engineer. The testimony of engineers of the highest professional reputation is fully given to his capacity and attainments, and to the excellence of the work he has done. As the final result of their examination and inquiry, the board are unanimous in the opinion that he best embraces the qualifications most important for the discharge of the responsible duties of city engineer."

It is to be noted that at the time of his election his age was thirty-five years. He was city engineer only from 1872 to 1880, when he resigned to accept a more important position, but during that comparatively brief time he completed an additional water supply for Boston, and, after visiting Europe and studying the sewerage systems of the larger cities, planned and began the construction of the comprehensive works for improved sewerage, now called the Main Drainage Works of Boston; but this was by no means the extent of his achievements in this position. He at once established the engineering of the city in all departments under his charge on a thoroughly sound basis.

At the time of Mr. Davis's election as city engineer, the office had been organized only three years. His principal assistants were a group of young men who were extremely fortunate in having the benefit of the excellent engineering training which

Mr. Davis could give, and in being subject to the remarkable influence which he had upon those with whom he was associated. He was thoroughly appreciative of the endeavors of his subordinates to do good work, and there are many of them who recall with pleasure and gratitude the time spent in service under his direction. Not only were these subordinates so greatly benefited by association with him, but they became so imbued with his views and methods that long after he resigned as city engineer his influence was a controlling factor in the conduct of the engineering work of the city.

Mr. Davis was chief engineer of the American Bell Telephone Company and its successor, the American Telephone and Telegraph Company, for twenty-five years, from 1880 to 1905, when failing eyesight compelled him to retire. During this time his duties with the telephone company were not confined to his position as chief engineer. He was vice-president and general manager of the Metropolitan Telephone Company of New York from 1880 to 1886, president of the Hudson River Telephone Company from 1889 to 1895, and of the Westchester Telephone Company from 1890 to 1893.

He acted as consulting engineer of boards and commissions on many important undertakings, including the Croton Aqueduct Commission from 1884 to 1886, the Massachusetts State Board of Health from 1886 to 1904, the Metropolitan Water Board and its successor, the Metropolitan Water and Sewerage Board, from 1895 to 1909; and the Metropolitan Sewerage Commission in 1898.

Mr. Davis was one of those who were active in the revival of our Society in 1874. He became its President in 1880, and in 1908 was elected an honorary member. He was a member, director and vice-president of the American Society of Civil Engineers, and one of the writers of this memoir knows that he would have been president of that Society had he not positively declined to accept the nomination. He was also a member of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the Institute of Electrical Engineers of England, and of the Century Club of New York. He was an honorary member of the New England Water Works Association.

At the time when Mr. Davis's eyesight failed to the extent that he was obliged to give up active business, he had a home in Yonkers, N. Y., and he continued to live there until his death. His sister who lived with him died after a few years, so that he had no relatives with him for nearly ten years. His trips to the city of New York became more and more infrequent. He did not become totally blind, but could read only with the help of a powerful magnifier, and went about with increasing difficulty. Notwithstanding these conditions, his mind was alert and he kept well informed as to the news of the day, and was generally bright and cheerful.

Reference has already been made to Mr. Davis's strong influence over his assistants while city engineer of Boston. Mention has often been made by these men of the influence which he has had upon their lives. His influence was not limited to them, but was felt by all those with whom he came in contact.

One who was with him during all the later years of his life makes this statement:

"One of the most beautiful tributes to Mr. Davis's influence as a man, from my point, was in the many letters that came to him from time to time from men whose names he had forgotten, but who had been under him as young men. One of these letters ran something like this: 'You have doubtless forgotten me, but I can never forget you or your influence over me and all the boys in your office. I owe you an everlasting debt, and think of you constantly. I have a good income, an attractive home, and wife and children of the best, and feel that I owe this result in large part to your influence and training.'"

The statement also says:

"Mr. Davis would hand these letters to me with such a modest air — and yet with such satisfaction — and say, 'Perhaps you would like to read this, but I do not deserve what he says.'"

One of the writers of this memoir has called on Mr. Davis nearly every year since 1905, and there appeared to be little change in his condition from year to year, but in January, 1917, it was noticed that although he seemed fairly well, he was not quite what he had been. During the winter his walks were

shorter, and unless the weather was favorable he would not go beyond the piazza. He would tire of his evening reading rather sooner than the year before, but, except for these slight changes, he was well to the day before his death.

On March 30 last, he went out for his usual walk after luncheon, and returned in good spirits. At dinner time he did not appear as usual, and upon investigation it was found that he was lying unconscious on the floor of his room. He evidently had been dressing for dinner when the stroke came, and apparently had suffered no pain. He remained unconscious until late the next day, when he passed away.

Mr. Davis was a delightful companion and had a most genial and happy disposition. His associates of many years speak of him as one whom it was a supreme pleasure to know.

Mr. Theodore Cooper says of him:

"He never relaxed either in business or in personal intercourse from the highest and noblest standards. He was always one of my best and staunchest friends, and one for whom I had the highest regard."

Mr. Charles Macdonald writes:

"I would say that Joseph P. Davis was in the very best sense the ideal type of an engineer, with a mind carefully trained to investigate nature's laws and the ability to apply those laws for the benefit of his fellow-men. He never hesitated to attack even the most complicated problems with a confidence of success which is the true inspiration for great achievement.

"In his solution of the water supply and sewerage system of Boston he was able to present such convincing facts, coupled with a rare diplomatic skill, as to effectually harmonize all conflicting interest; with the result that the greatest good has been accomplished with a minimum expenditure, which, after all, is the true test of engineering excellence.

"With such an equipment it is not to be wondered at that his advice and coöperation were eagerly sought for elsewhere, as the record indicates.

"As a man among men his guiding motive was to do that which was right, without a shadow of turning, and to promote peace and good-will among those with whom he had to do."

HAROLD PARKER.*

Died November 29, 1916.

Harold Parker was born in Charlestown, Mass., June 17, 1854, the son of George Alanson and Harriet Newhall Felton Parker, and was a direct descendant of Capt. Joseph Parker, who settled in Newbury in 1638, and of Nathaniel Felton, who settled in Salem in 1633.

After receiving a preliminary private school education in Philadelphia, Pa., and in Lancaster, Mass., he entered Phillips Exeter Academy, from which he graduated, and then entered Harvard College, continuing his studies there during 1871 and 1872.

Leaving college for a business career, he was first employed as foreman with the Pennsylvania Steel Company and later in the operating department of the Pennsylvania Railroad.

In 1874 he returned to his home town, Lancaster, Mass., and entered upon the practice of civil engineering, organizing in 1882 the civil engineering firm of Parker & Bateman, afterward Parker, Bateman & Chase, remaining a member of this firm until his death.

For a time he was actively engaged in railroad construction, in which work he was associated with his father, George A. Parker, who was an eminent engineer. In the early '80s they built the Charlottesville & Rapidan Railroad in Virginia, and in 1886–87 the Zanesville & Ohio River Railway in Ohio.

Notwithstanding the fact that he was of modest disposition and was not of the office-seeking type, he was prominent in the public affairs of his home town of Lancaster, and was twice elected to represent his district in the legislature. His best years in public service, however, were devoted to the work of building up the state highway system of his native state of Massachusetts. In 1900 he was appointed by the Governor as member of the Massachusetts Highway Commission, and upon the resignation of William E. McClintock in June, 1908, he was made chairman, which position he held until 1911, when he resigned to again devote his time to other than public office. His ability and tire-

* Memoir prepared by Arthur W. Dean and William E. McClintock.

less industry added to the good repute for gaining progress and results for which this commission had already become widely known. The revolution in methods of highway transportation and consequent revolution in methods of highway construction was at its height during Mr. Parker's administration as chairman, and to his thought and foresight are many indebted who are continuing the work so ably carried on by him. In 1908 he was appointed by the Governor of Massachusetts to represent the Commonwealth at the International Road Congress, held in France.

Immediately following his resignation as highway commissioner, he became vice-president of a large contracting firm, thus continuing to devote his time to road and pavement work.

In 1913 and 1914 Mr. Parker served the state of New York in an advisory capacity, being designated by Governor Dix as a member of the advisory board of the highway department.

Being a lover of nature, he spent his leisure in the fields and woods, taking much interest in the forests and natural resources of his neighborhood and state, and considering as a pleasure rather than a duty his services as chairman of the Massachusetts Forestry Commission and of the Wachusett Mountain Reservation Commission.

Indication of his recognition by others in his chosen field of effort is shown by his selection as president of the Massachusetts Highway Association and of the American Road Builders' Association, in both of which societies he took great interest.

He was a man of the sturdy New England type, of high principles, and a most true friend to those who won his friendship.

Mr. Parker is survived by his widow, Elizabeth B. (Bartol) Parker, to whom he was married in 1884, and by one son and two daughters.

Mr. Parker was a member of the American Society of Civil Engineers from 1899 until his death, and was elected member of the Boston Society of Civil Engineers on March 21, 1894. His interest in this Society is shown in a material way by his gift of several valuable volumes to the library.

Richard A. Hale
President, Boston Society of Civil Engineers
1916–1917

Vol. IV JANUARY, 1917 No. 1

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, JANUARY 24, 1917,

at 8.00 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Past-President Desmond FitzGerald will exhibit some of his colored lantern slides of travel and explain them in an interesting talk.

The Committee on Social Activities has arranged for a supper, to be served in Chipman Hall for members and their ladies, before the meeting. A special notice will be sent out later.

S. E. TINKHAM, *Secretary.*

PAPER IN THIS NUMBER.

"Catch-Basin Construction and Maintenance." Topical discussion.

CURRENT DISCUSSION.

Paper.	Author.	Published.	Discussion Closes.
"The Portland Bridge."	E. E. Pettee.	Dec.	Feb. 10

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

BINDING SOCIETY JOURNAL.

THE Secretary has made arrangements for binding Volume 3 of the JOURNAL of the Society. The ten numbers will be bound in one volume, the style of binding to be uniform with that of Volumes 1 and 2. Because of the increased cost of material, the price of binding this year will be 80 cents per volume.

Numbers for binding must be sent to 715 Tremont Temple, Boston, before March 1, 1917, in order to be bound at the price named.

MINUTES OF MEETINGS.

BOSTON, MASS., December 20, 1916. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 8.20 o'clock by the President, Richard A. Hale.

There were present 55 members and guests.

The record of the last meeting was approved as printed in the December JOURNAL.

The President reported for the Board of Government the election of the following to membership in the Society in the grades named:

Members — Messrs. William Allen Bryant, Arthur William Knowlton, Conrad Nolan and Erving Mandeville Young.

Associate — Mr. Charles Edward Kingston Fraser.

Juniors — Me srs. Anthony Andrew Breen, Alexander Bresth, Charles Leavett Crosier, Ray Osborn Delano and Henry Elmer Strout, Jr.

The President announced the deaths of the following members of the Society:

William H. Jaques, died November 23, 1916; Harold Parker, died November 29, 1916; and Edmund B. Weston, died December 9, 1916.

By vote, the President was requested to appoint committees to prepare memoirs.

The President has named the membership of these committees as follows:

On memoir of William H. Jaques, Prof. Ira N. Hollis; on memoir of Harold Parker, Messrs. Arthur W. Dean, William E. McClintock and Frederic W. Bateman; on memoir of Edmund B. Weston, Mr. Otis F. Clapp.

Mr. E. M. Blake brought to the attention of the Society the desirability of a committee to collect information and report on the best figures of run-off in New England which are available for water-power purposes. He moved the following resolution: "Resolved that the President be and hereby is authorized to appoint a committee to collect, compile, analyze and report upon the best figures of run-off in New England which are available for water-power purposes."

The resolution was adopted by a unanimous vote. The President has appointed, as the committee authorized by the resolution, Messrs. Arthur T. Safford, chairman; Harold S. Boardman, X. Henry Goodnough, Richard A. Hale, Chas. H. Pierce, George E. Russell, Charles W. Sherman, Herbert A. Moody, W. Frank Uhl, Joseph F. Wilber and Dana M. Wood.

The President then introduced Mr. Arthur E. Morgan, president of the Morgan Engineering Companies, of Dayton, Ohio, who read a most interesting paper entitled, "Flood Control in the Miami Valley." The paper was very fully illustrated by lantern slides. At the conclusion of the paper a short discussion took place, in which Mr. E. S. Dorr, President Hale and Past-President Eddy participated.

After passing a unanimous vote of thanks to Mr. Morgan for his very interesting paper, the Society adjourned.

S. E. Tinkham, *Secretary.*

Boston, Mass., December 27, 1916. — A special meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in the Society Library, Tremont Temple.

The meeting was opened at 7.45 by the vice-chairman, Edward Wright, Jr.

The minutes of the December meeting were read and approved.

The speaker was Mr. Theodore R. Kendall, engineer in

charge, who gave a very nteresting talk on "The Agua Clara Filtration Plant at Gatun, C. Z." Illustrations by lantern slides added to the value of the description.

Voted : To extend the thanks of the Section to Mr. Kendall for giving the address of the evening.

There were 29 present. Meeting adjourned at 9.15 o'clock.

FRANK A. MARSTON, *Clerk*.

APPLICATIONS FOR MEMBERSHIP.

[January 4, 1917.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BARRY, CHARLES GARDNER, Sandwich, Mass. (Age 39, b. Melrose, Mass.) Student at Mass. Inst. of Technology, 1895–1900, civil engineering course. From June, 1900, to September, 1905, rodman, instrumentman, inspector, etc., with B. & M. R. R.; from September, 1905, to March, 1906, with N. Y. C. & H. R. R. R. on grade-crossing elimination, etc.; from March, 1906, to June, 1909, instrumentman on Penn. R. R. tunnels; from June, 1909, to March, 1910, with N. Y. C. & H. R. R. R. on surveys and estimates for tunnel and dam; from April, 1910, to November, 1914, with Cape Cod Construction Co., in charge of field party and main office drafting room; since fall of 1915, of firm of Barry & Gurney, engineers and surveyors, Buzzards

Bay, Mass. Refers to A. S. Ackerman, C. B. Breed, J. J. Rourke, and C. M. Spofford.

Boas, Benjamin, Dorchester, Mass. (Age 26, b. Boston, Mass.) Graduate of Lowell Institute, 1910. During 1909 with Whitman & Howard, civil engineers; from 1910 to 1912 with Metropolitan Water Board, Engineering Department; from 1912 to 1914 resident engineer on construction work with Goodyear Tire & Rubber Co. of Akron, Ohio; during 1915 with Mass. Harbor & Land Commission, engineering department; is now resident engineer on construction work with Monks & Johnson. Elected a junior, October 16, 1912, and now desires to be transferred to grade of member. Refers to L. B. Ellis, Clifford Foss, W. E. Foss and Mark Linenthal.

Burnes, George Robert, Revere, Mass. (Age 26, b. Salem, Mass.) Graduate of Mass. Inst. of Technology, 1913, civil engineering course. From June to October, 1913, transitman with City of Chelsea, Mass.; from October, 1913, to 1914, in Boston office of Concrete Steel Company; from 1914 to date, assistant city engineer and superintendent of Street Division, Revere, Mass. Elected a junior, April 15, 1914, and now desires to be transferred to grade of member. Refers to C. F. Allen, C. B. Breed, J. A. O'Brien, C. G. Richmond and C. M. Spofford.

Clarkson, Edward Hale, Jr., Cambridge, Mass. (Age 23, b. Auburndale, Mass.) Graduate of Mass. Inst. of Technology, 1915, sanitary engineering course, degree of S.B. Is now assistant in civil and sanitary engineering department, Mass. Inst. of Technology. Refers to H. K. Barrows, C. B. Breed, J. W. Howard, Dwight Porter, C. M. Spofford and G. C. Whipple.

Jerome, Frank Jay, Toledo, Ohio. (Age 26, b. Painesville, Ohio.) Graduate of Mass. Inst. of Technology, 1914, civil engineering course, degree of S.B. From July, 1914, to date, with N. Y. C. R. R., line west of Buffalo; is now assistant engineer in resident engineer's office, Toledo, Ohio. Elected a junior, May 21, 1913, and now desires to be transferred to grade of member. Refers to C. F. Allen, C. B. Breed, A. E. Burton and C. M. Spofford.

Mattson, William Rhoads, Brookline, Mass. (Age 26, b. Philadelphia, Pa.) Graduate of Mass. Inst. of Technology, 1913, civil engineering course, degree of B.S. During summers of 1910, 1911 and 1914, fourteen months in all, rodman, transitman and chief of party with Brookline Engineering Department; during winter of 1914–15 made engineering and economic study of wages and living conditions for Bay State St. Ry. Co., under direction of A. S. Richey; during summer of 1915, chief engineer on two construction jobs for Aberthaw Construction Co.; with Mass. Highway Commission for four months in 1912 as transitman and chief of party; for nine months in 1913 and four months in 1915, as engineer in Maintenance Dept.; and for nine months, to date, as resident engineer on construction work. Refers to A. E. Burton, R. W. Coburn, A. M. Lovis, A. P. Rice, G. P. Soutar, C. M. Spofford and A. E. Tarbell.

Monaghan, John E. L., Boston, Mass. (Age 39, b. Oldham, England.) Graduate of Mass. Inst. of Technology, 1906. From 1906 to 1915, assistant engineer; during 1915, assistant district engineer, and from 1916 to date,

district engineer with City of Boston. Refers to T. F. Bowes, J. E. Carty, C. H. Dodd, E. S. Dorr, D. P. Kelley and J. M. McNulty.

NASH, PHILIP CURTIS, Watertown, Mass. (Age 26, b. Hingham, Mass.) Graduate of Harvard University, 1911, degree of A.B.; and of Harvard Graduate School of Applied Science, 1912, degree of M.C.E. From 1911 to 1912 with Boston Transit Commission on subway construction; is now assistant engineer with Boston Transit Commission on construction of Section G of Dorchester Tunnel. Elected a junior January 22, 1913, and now desires to be transferred to grade of member. Refers to E. S. Davis, W. W. Davis, F. C. H. Eichorn, G. D. Emerson, L. B. Manley and G. F. Swain.

SIMONS, GEORGE W., Jr., Jacksonville, Fla. (Age 25, b. Portland, Ore.) Graduate of Beloit College, 1912, degree of B.S.; graduate of Mass. Inst. of Technology, 1915, sanitary engineering course. From July to September, 1913, draftsman with Aetna Engineering Bureau, Chicago; during summer of 1915, assistant to Prof. G. C. Whipple, Harvard University; during 1915–16, assistant in civil engineering department, Mass. Inst. of Technology; from July, 1916, to date, chief, Bureau of Sanitary Engineering, Florida State Board of Health. Elected a junior, January 27, 1915, and now desires to be transferred to grade of member. Refers to H. K. Barrows, Dwight Porter, C. M. Spofford, R. S. Weston and G. C. Whipple.

LIST OF MEMBERS.

ADDITIONS.

CROSIER, CHARLES L. . . . . 316 Huntington Ave., Boston, Mass.
FRASER, CHARLES E. K. . . . . Peterboro, N. H.
YOUNG, ERVING M. . . . . 380 West Main St., Waterbury, Conn.

CHANGES OF ADDRESS.

CLARK, FRANK W. . . . . 10 Lynnfield Parkway, Melrose, Mass.
HUBBARD, CARL P. . . . . New Milford, Conn.
HURD, STEPHEN P. . . . . 247 West Main St., East Aurora, N. Y.
JOHNSON, ERIC L. . . . . 23 Irma Ave., Watertown, Mass.
KENDALL, THEODORE R. . . . . 93 Gainsborough St., Boston, Mass.
KLINK, NASSIME S. . . . . Care Aberthaw Construction Co.,
Water and Chestnut Sts., New Haven, Conn.
SHAW, ARTHUR L. . . . . 967 Robeson St., Fall River, Mass.
SMITH, CHESTER W. . . . . 208 Granite St., Manchester, N. H.
SMULSKI, EDWARD . . . . 2501 Park Row Bldg., New York, N. Y.
VON LOESECKE, SIDNEY S.
Automobile Legal Association, 6 Beacon St., Boston, Mass.

DEATH.

WESTON, EDMUND B. . . . . December 9, 1916

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

No. 384. Age 40. Tufts College, class of 1898. Has had seventeen years' experience, including two years in city engineer's office, Everett, Mass.; three and one-half years with Metropolitan Water Board on Wachusett Reservoir; two years with Bureau of Sewers, Brooklyn, N. Y.; six and one-half years with New York Board of Water Supply on Catskill Aqueduct; two years as superintendent for engineering firm in New York City on large sewer work in Bronx; and one year as engineer and superintendent on docks, pile driving and sewer outlets. Desires position as engineer or superintendent of construction. Salary desired, $200 per month.

No. 385. Age 30. Student for three years at Harvard University, Lawrence Scientific School, class of 1907. Has had experience as rodman, leveler and topographer on railway surveys in Arizona; as transitman in charge of lines and grades on subway construction for Boston Elevated Railway Co.; as transitman on construction of Cape Cod Canal; as inspector for Boston Transit Commission on Dorchester Tunnel; and as assistant engineer on farm reclamation and general land surveys for United Fruit Co., Panama.

No. 386. Age 26. High-school education. Has had eight years' general experience as surveyor and draftsman, including seven years on high-tension transmission lines, water-power development, highways, etc.; six months as chief of party on surveys for water-works system; and six months as chief of party on valuation work for Rhode Island Company. Desires position as chief of party, transitman or draftsman. Salary desired, $18 per week.

No. 387. Graduate of Technical High School and I. C. S. student in civil engineering. Has had three and one-half years' experience as rodman, transitman, draftsman and chief of party on railroad and municipal work. Desires position as transitman. Salary desired, $15.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Annual Report of Governor of Panama Canal for 1915–16, with Maps and Diagrams.

Barytes and Strontium in 1915. James M. Hill.

Flow of Water in Wood-Stave Pipe. Fred. C. Scobey.

Gold, Silver, Copper, Lead, and Zinc in California and Oregon in 1915. Charles G. Yale.

Iron Ore, Pig Iron and Steel in 1915. Ernest F. Burchard.

Mineral Waters in 1915. Richard B. Dole.

Phosphate Rock in 1915. W. C. Phalen.

Quicksilver in 1915. H. D. McCaskey.

Spirit Leveling in Texas, 1896 to 1915, inclusive. R. B. Marshall.

Water-Supply Papers 362-A, 381, 382, 415.

State Report.

Ohio. Official Plan of Miami Conservancy District for Protection of District from Flood Damage, Vols. I and III.

Municipal Reports.

Lynn, Mass. Annual Report of Commissioner of Water Works for 1915.

North Shore Sanitary District, Lake County, Ill. Report of Board of Engineers, 1916.

Philadelphia, Pa. Annual Report of Bureau of Surveys for 1915.

Miscellaneous.

American Society for Testing Materials: Proceedings for 1916, 2 vols.

Chemins de Fer. Amédée Guillemin. Gift of E. C. Sherman.

Electric Railways. Robert Luce. Gift of H. S. Knowlton.

Maintenance of Way and Structures. William C. Willard.

Municipal Index, August, 1912, to December, 1915.

Passenger Terminals and Trains. John A. Droege.

The duplicates listed below have been placed on the ends of the tables in the reading-room, and members are invited to help themselves.

American Society for Testing Materials: Proceedings, 1914–15, 4 vols., one bound in cloth.

American Society of Civil Engineers: Proceedings, January–April, August–October, 1912; January, April, September, October, December, 1913; January–April, August, September, 1914; Transactions, December, 1914.

Boston, Mass.: Annual Reports of Public Works Department for 1911, 1913, 1914; Annual Reports of Street Department for 1892, 1910; Annual Report of Street Laying-out Department for 1896; Annual Reports of Transit Commission for 1895, 1896, 1901.

Cambridge Bridge Commission's Report, 1909, 2 copies.

Chicago, Ill.: Report on Diversion of Waters of Great Lakes by Way of Sanitary and Ship Canal of Chicago. Lyman E. Cooley. 1913.

Connecticut: Annual Reports of Railroad Commissioners for 1896–98, 1900–1911; Annual Report of Public Utilities Commission for 1914.

Electric Railway Journal: December 4, 1915; February 19, 1916.

Engineering Magazine: Vol. 1, April–September, 1891, bound; October, 1909; Vol. 43, April–September, 1912, complete; December, 1914; January, March, May, 1915.

Interstate Commerce Commission: Annual Reports for 1900–1911.

Manual of Topographical Drawing. Lieut. R. S. Smith. 1856.

Massachusetts: Special Report of Railroad Commissioners on Bussey Bridge Investigation, 1887; Annual Reports of Railroad Commissioners for 1877 (Part 2); 1880–84; 1886–90; 1892–95; 1896–1912; Annual Reports of State Board of Health for 1894; 1911–12.

Municipal Journal: August 12, September 23, 1915; January 6, 1916.

New York: Annual Reports of Public Service Commission

for First District for 1910, 1911, 1912 (Vols. 1 and 3), 1914 (Vol. 2); Annual Reports of State Engineer and Surveyor for 1910–12.

Pennsylvania: Annual Report of Water Supply Commission for 1913.

Pittsburgh, Pa.: Report of Flood Commission, 1911.

Treatise on Resistance of Materials. De Volson Wood. 1871.

U. S. War Department: Wave Action in Relation to Engineering Structures. Capt. D. D. Gaillard. 1904.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the 1st of each month.)

United States Government. — NAVY DEPARTMENT. — *Navy Yard, Boston.* — Work being done consists of a dry coursed rubble sea wall at the Naval Hospital, Chelsea, Mass.

Work proposed consists of the installation of two 2 500 cu. ft. air compressors, compressors now on hand.

Commonwealth of Massachusetts.—METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.*

Wellesley Extension High Level Sewer: Sects. 98 and 102, in progress; Sect. 103, completed; Sect. 104, nearly completed.

New work is contemplated as follows: Reading extension; Sects. 99–101, Wellesley extension.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

Charles River Reservation. — Building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown. A. G. Tomasello, contractor.

Mystic Valley Parkway. — Grading extension of Mystic Valley Parkway from Mystic St. to Medford St., Arlington. James H. Fannon, contractor.

Old Colony Parkway. — Plans and specifications are being prepared for bridge over the Neponset River, Boston and Quincy, to replace old wooden bridge. Bids to be called for about the first of the year.

Boston Transit Commission. — *Dorchester Tunnel.* — The Dorchester Tunnel has been practically completed from its beginning at Tremont St. to a point under Dorchester Ave. near Broadway in South Boston.

Work is progressing on the Broadway Station, which extends in Dorchester Ave. from Broadway to West Fourth St. The T. A. Gillespie Co. is the contractor.

Work on Section G, which extends in Dorchester Ave. from West Fourth St. to Old Colony Ave., is in progress. Coleman Brothers are the contractors.

Section H and Section H Extension, which are completed, extend in Dorchester Ave. from Old Colony Ave. to near Dexter St.

The next section, Section J, extending from a point near Dexter St. in a southerly direction in and near Dorchester Ave. and Boston St. to near Ralston St., and embracing the station in Andrew Sq., is being constructed. The T. A. Gillespie Co. is the contractor.

The relaying of the granite-block paving, with grout joints and on a concrete base, in Dorchester Ave. from Old Colony Ave. to Humboldt Pl. near Andrew Sq., has been interrupted by the severely cold weather and will be resumed as early in the season as the weather will permit. The T. A. Gillespie Co. is the contractor.

New York, New Haven & Hartford R. R. Co. — *Boston, Mass., Southampton Street Engine Facilities.* — Work consists of new 39-stall engine house, 95-ft. turntable, ash pits, boiler house, office building, water tank and necessary trackage.

During past month have been excavating for engine house, office building and turntable foundations; driving concrete piles for engine house and wooden piles for turntable; erecting temporary building, etc.

Vol. IV FEBRUARY, 1917 No. 2

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, FEBRUARY 21, 1917,

at 8.00 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. James W. Rollins will give a talk on "The New Boston Dry Dock." The talk will be illustrated with lantern slides.

S. E. TINKHAM, *Secretary.*

PAPERS IN THIS NUMBER.

"Flood Control in the Miami Valley," Arthur E. Morgan.

Discussion of "The Groined Arch as a Means of Concrete Floor Construction."

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

BINDING SOCIETY JOURNAL.

THE Secretary has made arrangements for binding Volume 3 of the JOURNAL of the Society. The ten numbers will be bound

in one volume, the style of binding to be uniform with that of Volumes 1 and 2. Because of the increased cost of material, the price of binding this year will be 80 cents per volume.

Numbers for binding must be sent to 715 Tremont Temple, Boston, before March 1, 1917, in order to be bound at the price named.

ANNUAL MEETING OF THE SOCIETY.

The annual meeting of the Society will be held on Wednesday, March 21, 1917, at the Boston City Club, Ashburton Place, Boston.

The annual meeting for the transaction of business and the announcement of the result of the letter ballot for officers will be held at 12 o'clock M. A short address will be made by the retiring President.

The annual dinner will be served at two o'clock in the auditorium of the club.

In the evening, a smoker will be held in the auditorium, at which light refreshments, music, and other entertaining features may be expected.

Further details will be furnished in a special circular to be sent out early next month, and in the March Journal.

MINUTES OF MEETINGS.

Boston, Mass., January 10, 1917. — A special meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 8 o'clock by the President, Richard A. Hale.

Mr. Jacob Lowenstein, of the engineering department of the American Bridge Company, read a most interesting paper on "The Construction and Erection of Hell Gate Bridge." The paper was profusely illustrated with lantern slides and motion pictures. At the conclusion of the reading of the paper, Mr. Lowenstein kindly answered numerous questions in relation to the erection of the bridge.

On motion of Past President Fay, the thanks of the Society were extended by a unanimous rising vote to the American Bridge Company and its representative, Mr. Lowenstein, for their courtesy in presenting to the Society so valuable and instructive a paper.

The attendance at the meeting, including both members and guests, was 375.

S. E. Tinkham, *Secretary*.

Boston, Mass., January 24, 1917. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, Richard A. Hale. In the absence of the Secretary, Mr. F. O. Whitney served as Secretary *pro tem.*

There were present 91 members and guests, including 44 ladies. (The occasion was Ladies' Night, supper being served at 6.30 P.M.)

The record of the last meeting was approved as printed in the January Journal.

The President reported for the Board of Government the election of the following to membership in the Society in the grades named.

Members — Messrs. John Brazer Babcock 3d, Leslie P. Reed, George Summers Sawyer and Edward Van der Pyl.

Associate — Mr. Joseph A. Tomasello.

Junior — Mr. Freeman Hudson Horton.

The President announced the death of Walter N. Charles, who died January 20, 1917.

By vote, the President was requested to appoint a committee to prepare a memoir.

An invitation was read from the American Roadbuilders' Association inviting members of this Society to attend its convention to be held in the Mechanics Building, Boston, February 5 to 9, inclusive, and to name three delegates to represent the Society.

This invitation was accepted and the President was authorized to appoint three delegates.

The President named Messrs. Joshua Atwood, Lewis M. Hastings and William E. McClintock as delegates to the convention.

It was voted that the President appoint a committee of three to nominate a committee of five to nominate officers for the coming year.

The President appointed Messrs. Frank W. Hodgdon, Edward W. Howe and Sidney Smith a committee, who reported the names of Messrs. John E. Carty, Herbert R. Stearns, Herbert T. Gerrish, Sturgis H. Thorndike and John J. Rourke, who were elected a committee to report nominations for officers.

After welcoming the ladies, the President introduced Past President Desmond FitzGerald, who gave an interesting illustrated talk on his travels.

Adjourned at 9.30 o'clock.

FRANK O. WHITNEY, *Secretary pro tem.*

BOSTON, MASS., January 3, 1917. — A meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in Chipman Hall, Tremont Temple. The meeting was opened at 7.30 o'clock by the Chairman.

The first paper presented was by Raymond C. Allen, civil engineer, on the "Outfall Sewer and Pumping Station, Manchester, Mass." The paper described the engineering work required for the construction of a 14-in. cast-iron submerged outfall in Manchester Harbor, laid for a distance of over 8 000 ft. into deep water in the outer harbor. The paper also described the pumping station and storage wells with equipment.

The second paper was by Clarence A. Moore, assistant engineer, Metropolitan Water and Sewerage Board, on the "Extension of the Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor." The paper included a general description of the Metropolitan sewerage districts and the construction of a temporary outfall. The principal features were the construction of the outfall extension, methods, character of the

foundation and a description of the special multiple outlets, as well as many other features of interest.

Both papers were illustrated by lantern slides. The interest shown in these subjects is indicated by the attendance, which was 64, in spite of the fact that the night was very stormy. The meeting adjourned at 9 o'clock.

Frank A. Marston, *Clerk.*

APPLICATIONS FOR MEMBERSHIP.

[February 5, 1917.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Crocker, Harold Simpson, Brockton, Mass. (Age 28, b. Brockton, Mass.) Student at Mass. Inst. of Technology, 1909–1911, and at Franklin Union evening school, 1912–1914. From 1911 to April, 1916, with city engineer of Brockton; from April, 1916, to January 1, 1917, in private practice as civil engineer in Brockton; January, 1917, was elected city engineer of Brockton. Refers to G. E. Bolling, C. R. Felton, James Hayes, Jr., and R. S. Weston.

Pike, Waldo Francis, Cambridge, Mass. (Age 23, b. Cambridge, Mass.) Graduate of Mass. Inst. of Technology, 1915, civil engineering course. During one summer vacation employed in drafting room of N. E. T. & T. Co.;

from June, 1915, to January, 1916, template maker with New England Structural Company; from January to April, 1916, inspector in beam shop of same firm; from April to June, 1916, bridge inspector, and from June to September, structural draftsman, with B. & M. R. R.; from October, 1916, to date, with Fay, Spofford & Thorndike, Boston. Refers to C. R. Berry, F. H. Fay, B. W. Guppy, R. W. Horne, J. S. Lamson and C. M. Spofford.

Sheik, Henry Connor, Boston, Mass. (Age 22, b. Boston, Mass.) Graduate of Mass. Inst. of Technology, 1915, civil engineering course; took post-graduate work at M. I. T., 1916. During summer months, from 1907 to 1913, with Coughlan & Sheik, contractors; during summers of 1914 and 1915, with Coleman Brothers, contractors; is now with National Waterproofing Company, Boston. Refers to C. B. Breed, J. W. Howard, L. J. Johnson, Dwight Porter, C. M. Spofford and G. F. Swain.

LIST OF MEMBERS.

ADDITIONS.

Breen, Anthony A. . . . . 461 Somerville Ave., Somerville, Mass.
Horton, Freeman H. . . . . 12 Newbern St., Jamaica Plain, Mass.
Van der Pyl, Edward . . . . 46 Summerhill Ave., Worcester, Mass.

CHANGES OF ADDRESS.

Ackerson, Herbert N. . . . . 167 Babcock St., Quincy, Mass.
Badger, Frank S.
Care J. G. White & Co., 9 Cloak Lane, Cannon St., London, E. C., England
Burnes, George R. . . . . 11 Hyde St., Revere, Mass.
Eberhard, Walter C. . . . . 21 Church St., Rutland, Vt.
Flett, Louis E. . . . . 452 Willow St., Waterbury, Conn.
Hobson, George F. . . . . 1121 Columbia Road, N. W., Washington, D. C.
Howard, John L.
Metropolitan Water and Sewerage Bd., 1 Ashburton Place, Boston, Mass.
Kleinert, Albert E., Jr. . . . . . . 38 Hamilton Road, West Somerville, Mass.
Manley, Laurence B. . . . . 754 Bourse Bldg., Philadelphia, Pa.
Peacock, Frank E. . . . . 200 Bay State Road, Boston, Mass.
Sherman, Edward C.
Bureau of Yards and Docks, Navy Dept., Washington, D. C.

DEATH.

Charles, Walter N. . . . . January 20, 1917

EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

No. 388. Age 31. Student for two and one-half years at University of Maine, civil engineering course. Has had about seven years' experience, chiefly on surveys, including railway location; has served as rodman, instrumentman, chief-of-party, draftsman, and resident engineer on railroad construction; has had some experience in municipal work. Desires position on construction work with private engineer in or near Boston. Salary desired, $25 per week.

No. 389. Age 23. High school education. Has had five and one-half years' experience in surveying, making all field and office calculations and maps; worked up from position of chainman to that of chief-of-party; has worked one and one-half years as engineer on building construction. Desires position as transitman and time-keeper. Salary desired, $17 to $18 per week.

No. 390. Age 33. Graduate of Tufts College, 1906, civil engineering course, degree of B.S. Experience includes three and one-half years in engineering department, B. & M. R. R.; two and one-half years' cemetery work; three years in city engineering department, two and one-half of the three as city engineer; one and one-half years as superintendent of streets. Desires work on construction, preferably road work. Minimum salary desired, $1 800 per year.

No. 391. Age 23. Graduate of Rhode Island State College, 1916, civil engineering course, degree of B.S. Has had seven months' experience with maintenance of way department of railroad, chiefly as rodman and as transitman in charge of field parties; has also had some office experience in tracing, drafting, etc. Desires position as transitman. Minimum salary desired, $1 000 per year.

No. 392. Age 45. Private and high school education. Experience includes six years on street work in city surveyor's office; six months with gas light company on location of pipes, valves, etc.; three years with civil engineer on surveys; and about twelve years in private practice, making surveys for new buildings.

No. 393. Age 34. Graduate of University of Maine, degree of B.S.,

1906; degree of C.E., 1913. Experience includes six months of municipal and six months of railroad engineering in New Hampshire; six years with U. S. Reclamation Service in Idaho on drafting, surveys and construction; two years on general building construction and foundations in Boston and Cambridge; and two years as draftsman and superintendent on water supply and sewage disposal in Maine and Massachusetts. Desires position as engineer on operation or construction of public utility. Salary desired, $110 per month.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Analysis of Silicate and Carbonate Rocks. W. F. Hillebrand.

Annual Report of Chief of Weather Bureau for 1915–16.

Annual Report of Interstate Commerce Commission for 1916.

Annual Report of Superintendent, Coast and Geodetic Survey, for 1915–16.

Artesian Water for Irrigation in Little Bitterroot Valley, Montana. Oscar E. Meinzer.

Estimates of Population of United States, 1910 to 1916, inclusive.

Geographic Tables and Formulas. Samuel S. Gannett.

Geology of Upper Stillwater Basin, Stillwater and Carbon Counties, Montana. W. R. Calvert.

Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1915. Charles W. Henderson.

Gold, Silver, Copper, Lead and Zinc in New Mexico and Texas in 1915. Charles W. Henderson.

Gold, Silver, Copper, Lead and Zinc in Utah in 1915. V. C. Heikes.

Gypsum in Southern Part of Bighorn Mountains, Wyoming. Charles T. Lupton and D. Dale Condit.

Measurement of Silt-Laden Streams. Raymond C. Pierce.

Public Road Mileage and Revenues in New England States, 1914.

Public Road Mileage and Revenues in United States, 1914.
Sugar Pine. Louis T. Larsen.

State Reports.

Illinois. Bridge Manual for County Superintendents of Highways, Resident Engineers and Inspectors. Clifford Older.

Illinois. Report of State Board of Health on Sanitary Investigations of Illinois River and Its Tributaries, 1901. Gift of W. S. Johnson.

New Jersey. Revision of Primary Levels and List of Bench Marks in Northern New Jersey. C. C. Vermeule.

Ohio. Miami Conservancy District: Official Plan for Protection of District from Flood Damage, Vol. II; Report of Chief Engineer, 1916, 3 vols. bound in one. Gift of Arthur E. Morgan.

Oregon. Rules, Regulations, Forms and Practice of Office of State Engineer and State Water Board Relative to Control, Distribution and Use of Water Resources of Oregon. John H. Lewis and Percy A. Cupper.

Municipal Reports.

Atlanta, Ga. Annual Report of Water Commissioners for 1915.

Atlantic City, N. J. Annual Report of Water Department for 1915.

Denver, Colo. Annual Report of Department of Improvements for 1915.

Detroit, Mich. Annual Report of Department of Parks and Boulevards for 1916.

Kansas City, Mo. Annual Report of Fire and Water Commissioners for 1915–16.

Los Angeles, Cal. Complete Report on Construction of Los Angeles Aqueduct, 1916.

New York, N. Y. Report of Department of Water Supply, Gas and Electricity on Water Supply System, 1916.

Pasadena, Cal. How Other Cities in United States are Disposing of Their Sewage. T. D. Allin and R. V. Orbison.

Miscellaneous.

American Public Health Association: Reports and Papers, 1905–07. 6 vols. Gift of W. S. Johnson.

Canada, Department of Mines: Report on Production of Spelter in Canada, 1916. Alfred W. G. Wilson.

Handbuch für Specielle Eisenbahn-Technik. Edmund Heusinger von Waldegg. 4 vols. Gift of E. C. Sherman.

Portland Cement Association: Concrete Facts about Concrete Roads; Concrete Sewers; Concreting in Cold Weather; Farmer's Handbook on Concrete Construction.

Spray Engineering Co.: Washing and Cooling Air for Steam Turbine Generators.

Viaduct Works' Handbook. Henry N. Maynard. Gift of E. C. Sherman.

Duplicates to which members may help themselves will be found, as usual, on the ends of the tables in the reading-room. The list is as follows:

American Society of Civil Engineers: Final Report of Special Committee on Rail Sections, 1910; Index to Transactions, Vols. 22–27, 1893, and 46–59, 1901–07; Proceedings, August, 1911; September–December, 1913; January, February, August–November, 1914; January, February, April, 1915.

Illinois State Board of Health: Report of Sanitary Investigations of Illinois River and Its Tributaries, 1901.

Iowa State College, Engineering Experiment Station: Bulletin 43, Practical Handling of Iowa Clays.

Ohio, Miami Conservancy District: Official Plan for Protection of District from Flood Damage, Vols. 1 and 3. (Several copies of each.)

Ohio State Board of Health: Preliminary Report of Investigation of Rivers and Deep Ground Waters of Ohio as Sources of Public Water Supply, 1897–1898.

Massachusetts: Reports of Joint Board on Improvement of Charles River, April, 1894, and May, 1896. (Two copies of each.)

Massachusetts, Joint Board on Metropolitan Improvements: Final Report, 1911.

Massachusetts, Commission on Metropolitan Improvements: Report on Public Improvements for Metropolitan District, 1909.

Massachusetts, Harbor and Land Commissioners: Annual Reports for 1898, 1899, 1901, 1903–10, 1912.

Massachusetts, Metropolitan Park Commission: Annual Reports for 1896, 1897, 1900–1907, 1909–12.

Massachusetts, Metropolitan Sewerage Commission: Annual Reports for 1895–96; Report upon High Level Gravity Sewer for Relief of Charles and Neponset River Valleys, 1899.

Massachusetts, State Board of Health: Report on Sewerage of Mystic and Charles River Valleys, January, 1889.

United States, Bureau of Mines: Accidents at Metallurgical Works in United States during Calendar Years 1913 and 1914, compiled by A. H. Fay; Analyses of Coals, Part II, by N. W. Lord and others; Manufacture and Uses of Alloy Steels, by Henry D. Hibbard; Methods for Determining the Water in Petroleum and Its Products, by Irving C. Allen and Walter A. Jacobs; Prevention of Accidents from Explosives in Metal Mining, by Edwin Higgins; Saving Fuel in Heating a House, by L. P. Breckenridge and S. B. Flagg.

Library Committee.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the 1st of each month.)

Commonwealth of Massachusetts.—Metropolitan Water and Sewerage Board. — *Sewerage Works.* — Work in progress: Section 98, Dedham, Wellesley extension; Section 102, Wellesley extension (suspended for winter).

Work contemplated: Sections 99, 100, 101, Wellesley extension; Sections 76–75, Reading extension (6 000 ft. rock tunnel).

Metropolitan Park Commission. — *Charles River Reservation.* — The work of building reinforced concrete bridge over the Charles River at North Beacon St., Boston and Watertown, is in progress. A. G. Tomasello, contractor.

Mystic Valley Parkway. — The work of grading extension of Mystic Valley Parkway from Mystic St. to Medford St., Arlington, is in progress. James H. Fannon, contractor.

Boston Transit Commission.—*Dorchester Tunnel* has been practically completed from its beginning at Tremont St. to a point under Dorchester Ave. near Broadway in South Boston.

Work is progressing on the Broadway Station, which extends in Dorchester Ave. from Broadway to West Fourth St.

Work on Section G, which extends in Dorchester Ave. from West Fourth St. to Old Colony Ave., is substantially completed north of the N. Y., N. H. & H. R. R. Co. cut, except the resurfacing of the street. Work at and south of the railroad cut is now in progress.

Section H and Section H Extension, which are completed, extend in Dorchester Ave. from Old Colony Ave. to near Dexter St.

The next section, Section J, extending from a point near Dexter St. in a southerly direction in and near Dorchester Ave. and Boston St. to near Ralston St., and embracing the station in Andrew Square, is being constructed. The work is about three fourths done, the work remaining being in Boston St. and in the station south of Dexter St.

Commission on Waterways and Public Lands.— *Mystic River Dredging.* — The shoal place in the Mystic River between Chelsea and Malden bridges is being dredged to the depth of 30 ft. under a contract with the Maryland Dredging and Contracting Co., which calls for a total of 1 750 000 cu. yds. About 500 000 cu. yds. have been dredged, and the work is proceeding at the rate of about 125 000 cu. yds. per month. This work is being done with scoop dredges, and the material is being taken to East Boston and used for filling purposes there.

East Boston. — Material from the shoals in Mystic River

and also material from private dredging in various parts of the harbor is being brought to East Boston and dumped in two areas, whence it is rehandled by an hydraulic dredge to an area between the new bulkhead and Wood Island. An average of about 225 000 cu. yds. per month is being deposited in this way.

Dry-dock at South Boston. — The cofferdam has been completed and the dry-dock area has been pumped out with the exception of a small pool at the inner end. A steam shovel is at work excavating in the outer portion. A track has been constructed leading down into the pit. The pumping equipment has been installed and is in operation for keeping the excavation free from water.

State Pier at New Bedford. — The State Pier at New Bedford is completed except paving. Steel shed on pier erected, second floor of concrete is laid, first floor to be laid as weather permits.

Waterway between Taunton River and Massachusetts Bay. — Two parties in field-making survey for a proposed waterway between Taunton River and Massachusetts Bay.

Conservation of Water Sources. — One party in field-taking levels in connection with the investigation of the conservation of the water sources of the state.

City of Boston. — Public Works Department. — Highway Division, Paving Service.

Hill Top St.,	Granite Ave. to Hallet St.	Bituminous macadam.
Ralston St.,	Dorchester Ave. to Old Colony Ave.	Filling.

New York, New Haven & Hartford R. R. Co. — *Boston, Mass., Southampton Street Engine Facilities.* — Work consists of new thirty-nine stall engine house, 95-ft. turntable, ash pits, boiler house, office building, water tank and necessary trackage.

During past month have been excavating for engine house, office building and turntable foundations; driving concrete piles for engine house and wooden piles for turntable; pouring concrete for foundation of engine house.

Fore River Shipbuilding Corporation, Quincy, Mass., has the following work in progress:

Twenty-six submarines for United States Government.

Eight torpedo boat destroyers for United States Government.

One molasses boat for Cuba Distilling Company.

Two oil tankers for the Texas Company.

Two oil tankers for the Mexican Petroleum Company.

Four freight boats for Edgar F. Luckenbach.

Two freight boats for Fore River Shipbuilding Corporation.

One oil tanker for Argentine Government.

Vol. IV MARCH, 1917 No. 3

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

SIXTY-NINTH ANNUAL MEETING.

THE annual meeting of the Boston Society of Civil Engineers will be held at the Boston City Club, Ashburton Place, Boston, on Wednesday, March 21, 1917.

As previously announced, the annual meeting this year will consist of three principal features: a business meeting at noon, the annual dinner in the afternoon and the smoker in the evening.

PROGRAM.

Business Meeting. — The annual meeting required by the constitution will be called to order at 12 o'clock M., in the Assembly Room, on the third floor of the Clubhouse.

Business. — Announcement of the election of new members.

To receive the annual reports of the Board of Government, of the Treasurer and of the Secretary.

To receive the annual reports of the several special committees.

To reappoint the several special committees.

Announcement of the result of letter-ballot for officers for the ensuing year.

Presentation of the Desmond FitzGerald Medal.

Address of the retiring President.

Annual Dinner. — The thirty-fifth annual dinner will be served at half past one o'clock P.M., in the main banquet hall or auditorium on the fourth floor of the Clubhouse.

At three o'clock Mr. Frank M. Williams, state engineer and surveyor of the state of New York, will give a description

of the New York Barge Canal and Terminal Connections. Mr. Williams's address will be illustrated with lantern slides and motion pictures.

Smoker. — The usual informal smoker will be held in the evening, in the main banquet hall, beginning at 6.30 o'clock.

S. E. TINKHAM, *Secretary*.

PAPERS IN THIS NUMBER.

"Manchester, Mass., Outfall Sewer." Raymond C. Allen.

"Extension of North Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor." Clarence A. Moore.

Memoirs of deceased members.

CURRENT DISCUSSION.

Paper.	Author.	Published.	Discussion Closes.
"Flood Control in the Miami Valley."	Arthur E. Morgan.	Feb.	April 10.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, MASS., February 21, 1917. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order at 8.10 o'clock by the President, Richard A. Hale.

There were 125 members and visitors present.

The records of the special meeting of January 10, 1917, and of the regular meeting of January 24, 1917, were approved as printed in the February, 1917, number of the JOURNAL.

The President reported for the Board of Government the election of the following to membership in the Society in the grades named:

Members — Messrs. Charles Gardner Barry, Benjamin Boas, George Robert Burnes, Frank Jay Jerome, William Rhoads Mattson, John E. L. Monaghan, Philip Curtis Nash and George W. Simons, Jr.

Junior — Mr. Edward Hale Clarkson, Jr.

Past President Gow brought before the Society the matter of aiding in the present preparedness movement, and said in part:

"I have recently heard frequent suggestions made by some of our members that a society of the nature of ours, embracing in its membership a collective ability, knowledge and experience which would be of invaluable aid to the community in case of serious emergency, could render very efficient service to the constituted authorities by offering its loyal coöperation in connection with the present preparedness movement now under way in this state.

"As a majority of the members undoubtedly are aware, there has recently been appointed by the Governor of the Commonwealth, a committee of one hundred citizens, known as a Committee on Public Safety, created for the purpose of studying questions involved in adequately protecting the community against the possible hostile acts of a public enemy. This committee has delegated the details of management to an executive committee, which in turn has appointed various sub-committees of citizens to cover particular features of the main problem. Already there have been named some fourteen sub-committees, but as yet no committee on engineering has apparently been contemplated by the executive committee.

"I believe, and I hope you all believe with me, that at this critical moment in our history, when all citizens have an opportunity to demonstrate their loyalty to country and to state, our Society should not be backward in at least volunteering its assistance to those public authorities who may stand in need of such help.

"If the initiative is taken by the Society, I assume that we might be requested to name a representative engineering com-

mittee that would be competent to study and report upon any engineering detail, civil, sanitary or structural, which might arise in the consideration of a proper defensive system.

"In order to bring this matter properly before the Society, I move, Mr. President, that the Society tender its services to the Massachusetts Committee on Public Safety for such duties or services as this committee may request of it."

The motion was seconded by Past President FitzGerald and adopted by a unanimous vote.

The Secretary presented the following memoirs of deceased members, which had been prepared by committees of the Society: That of Edward D. Bolton, prepared by Frederick M. Hersey and Daniel W. Pratt, committee; that of Thomas F. Richardson, prepared by Hiram A. Miller, committee; and that of Frank E. Shedd, prepared by Mr. Frank W. Reynolds, of Boston, submitted by Charles T. Main, committee.

By vote, the memoirs were accepted and ordered printed in the JOURNAL of the Society.

The President then called on Past President James W. Rollins, who gave a most interesting account of the work that had already been done on the construction of the Boston Dry Dock. The description was very fully illustrated by lantern slides.

A discussion followed, in which Messrs. Frank W. Hodgdon, Charles R. Gow, Lewis E. Moore, C. Frank Allen, and others took part.

Adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., February 7, 1917.— A regular meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in the Society Library, Tremont Temple.

The meeting was opened at 7.30, by the chairman, Frederic Bonnet, Jr.

The chairman appointed the following committee to nominate officers for the coming year: Messrs. Edmund M. Blake, chairman; George A. Sampson and Arthur D. Marble.

On motion of Mr. A. L. Fales, it was voted "to authorize

the chairman to appoint a special committee to study, collect data and report upon the distribution of excessive rainfall in Boston and vicinity."

The chairman spoke to the members regarding the coöperation of sanitary engineers with the government in military affairs, and suggested that the Section take some action in the matter. The question was discussed by Professor Whipple and Messrs. King and Wright.

On motion of Mr. George A. King, it was voted that the Executive Committee be empowered to confer with the main Society with regard to taking some action in the matter.

The speaker of the evening, ex-Chairman Stephen DeM. Gage, gave a very interesting talk on "Sewage Disposal in Rhode Island."

It was voted to extend a rising vote of thanks to Mr. Gage, for his interesting talk.

There were 42 present, and the meeting adjourned at 9.20 P.M.

(Signed) John P. Wentworth,
Clerk pro tem.

APPLICATIONS FOR MEMBERSHIP.

[March 5, 1917.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members

as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Coburn, Stuart E., Norwood, Mass. (Age 26, b. Walpole, Mass.) From September, 1913, to October, 1915, chemist with sewer department, city of Worcester, Mass.; from October, 1915, to date, with Metcalf & Eddy, during which period has been located at Norwood in direct charge of control work and experimental work on wastes from tannery of Winslow Bros. & Smith Co. Refers to Frederic Bonnet, Jr., H. P. Eddy, A. L. Fales and R. S. Lanphear.

Coffin, Grover Cleveland, Nantucket, Mass. (Age 28, b. Nantucket, Mass.) Graduate of Nantucket High School, 1906; completed prescribed course as apprentice draftsman with General Electric Co., Lynn, Mass., 1909; during winter of 1911–12, student at Boston Y. M. C. A., railroad engineering course; winters of 1912–13 and 1913–14, student at Franklin Union; and in winter of 1915–16 completed first year Lowell Institute buildings course. From June, 1909, to April, 1910, draftsman with General Electric Co.; from April, 1910, to April, 1912, rodman with N. Y., N. H. & H. R. R. Co., construction engineer's department; from April, 1912, to October, 1913, rodman, and from October, 1913, to April, 1914, transitman with Metropolitan Water and Sewerage Board; from April, 1914, to November, 1915, salesman in real estate business; from November, 1915, to May, 1916, computer with Special Tax Committee on Revaluation, City of Cambridge; from May, 1916, to date, resident engineer with Massachusetts Highway Comm.; since January, 1917, temporarily employed as computer for Special Tax Committee, City of Cambridge, while on leave of absence from Massachusetts Highway Comm. Refers to J. J. Casey, J. J. Preble, C. H. Restall, F. D. Smith, and A. S. Tuttle.

Hanf, Frank Sidney, Chelsea, Mass. (Age 25, b. Saxonville, Mass.) Graduate of Chelsea High School, 1911, technical course; completed courses in railroad engineering, structural design, etc., at B. Y. M. C. A. Evening School and Franklin Union, during winters of 1911 to 1916, inclusive. From September, 1912, to May, 1913, chainman with real estate department, B. & M. R. R.; during May and June, 1913, draftsman with T. A. Appleton, C. E., Salem, Mass.; from June, 1913, to January, 1914, rodman with Massachusetts Highway Comm.; from January, 1914, to January, 1915, transitman, draftsman and chief-of-party with B. & A. R. R.; from January, 1915, to May, 1916, title researchman with valuation department, B. & M. R. R.; from May, 1916, to date, resident engineer on highway construction with Massachusetts Highway Comm.; since December, 1916, while on leave of absence from Massachusetts Highway Comm., temporarily employed as draftsman with valuation department, N. Y., N. H. & H. R. R. Refers to

Allen Curtis, R. W. Coburn, G. M. Harris, T. P. Perkins, F. B. Rowell and J. B. Russell.

MURPHY, JOHN W., Springfield, Mass. (Age 25, b. Beverly, Mass.) Graduate of Massachusetts Agricultural College, 1916, course in landscape architecture and civil engineering. From March, 1916, to date, with C. R. Parker, landscape architect, as superintendent of all construction of engineering nature, including sewerage, water supply, reinforced concrete work, road building, etc. Refers to A. B. Appleton, G. P. Connolly, S. J. Connolly, J. W. Raymond, Jr., and H. L. Whitney.

O'NEIL, JOSEPH LEON, Somerville, Mass. (Age 27, b. Cambridge, Mass.) Educated in public schools, including Concord, Mass., High School. Has been engaged in engineering work since 1907; employed on railway, sewer and city work by A. W. Sherry, New Haven, Conn.; on double-tracking of Boston & Worcester Railway by E. H. Rogers, chief engineer; on landscape work by E. W. Bowditch; and on valuation work by N. Y., N. H. & H. R. R. and B. & M. R. R. companies; is now draftsman with B. & M. R. R. Co. Refers to W. G. Burleigh, J. H. Duffy, S. J. Gulesian, G. M. Harris, Malcolm Rich, J. B. Russell and F. C. Shepherd.

LIST OF MEMBERS.

ADDITIONS.

BABCOCK, JOHN B.............Mass. Inst. of Technology, Cambridge, Mass.
CLARKSON, EDWARD H., Jr...............44 Langdon St., Cambridge, Mass.
STROUT, HENRY E., Jr......................11 Westerly St., Roxbury, Mass.
TOMASELLO, JOSEPH A....................73 Gibson St., Dorchester, Mass.

CHANGES OF ADDRESS.

DE LA HAYE, ELIAS F., Jr..................50 Perrin St., Roxbury, Mass.
DESMOND, EDWIN A......................90 Florida St., Dorchester, Mass.
DRUMMOND, WILLIAM W...Office of Quartermaster, Fort H. G. Wright, N. Y.
EISNOR, JOHN J..........................28 Bowdoin St., Medford, Mass.
ELKINS, CLAYTON R......................36 South Perry St., Dayton, Ohio
EMERSON, RALPH W.................Kinnell-Kresge Bldg., Pittsfield, Mass.
FERNALD, GORDON H.,
Care Milo H. Fernald, 908 8th St., San Bernardino, Cal.
FLETT, LOUIS E.........Care of Naugatuck Chemical Co., Naugatuck, Conn.
HARRIS, GILBERT M ....56 Charlesgate East, Boston, Mass.
HATHAWAY, ERWIN O....................512 St. Peter St., St. Paul, Minn.
KENDALL, THEODORE R.,
Care of *American City*, 87 Nassau St., New York, N. Y.
KIMBALL, HERBERT S.........................75 State St., Boston, Mass.
MCSWEENEY, THOMAS F.,
Technology Chambers, Irvington St., Boston, Mass.

Reed, Leslie P. . . . . Care of J. W. Bishop Co., Bridgewater, Mass.
Rew, Morse W. . . . . Care of Transit Commission, Pittsburgh, Pa.
Robinson, John R. . . . . Y. M. C. A., Newton, Mass.
Rourke, Louis K.,
Care of Chile Exploration Co., 120 Broadway, New York, N. Y.

DEATH.

Parker, Alfred W. . . . . February 24, 1917

EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

No. 394. Age 38. Received technical education at University of Pennsylvania, civil engineering course. Has had eight years' experience in railroad engineering, including preliminary and location surveys, maintenance and heavy construction; also four years' experience in general engineering and contracting. Would prefer position as maintenance engineer or superintendent of construction at large plant, but any position in line with above experience would be acceptable, provided location is permanent. Salary desired, $150 to $175 per month.

No. 395. Age 26. Graduate of Tufts College Engineering School, 1914, degree of B.S. Experience includes one year as draftsman, two years as rodman and instrumentman for transit commission, and seven months as instrumentman and inspector of road construction for highway commission. Desires position along civil engineering lines.

No. 396. Age 28. High school graduate; received technical education from I. C. S. course in civil engineering. Has had one and one-half years' experience as rodman and chainman. Desires position as rodman. Salary desired, $75 per month.

No. 397. Age 26. Graduate of Mass. Inst. of Technology, civil engineering course. Experience includes reinforced concrete detailing and design, also municipal work as assistant engineer and superintendent in charge of street division.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Accuracy of Stream-flow Data. (Water-Supply Paper 400-D). N. C. Grover and J. C. Hoyt.

Annual Report of Director of United States Geological Survey for 1915–16.

Borax in 1915. Charles G. Yale.

Clay-working Industries and Building Operations in Larger Cities in 1915. Jefferson Middleton.

Coal in 1915. Part A, Production; Part B, Distribution and Consumption. C. E. Lesher.

Coke in 1915. C. E. Lesher.

Copper in 1915. B. S. Butler.

Forest Fires in United States in 1915. J. Girvin Peters.

Gems and Precious Stones in 1915. Waldemar T. Schaller.

Gold, Silver, Copper, Lead and Zinc in Arizona in 1915. V. C. Heikes.

Gold, Silver, Copper, Lead and Zinc in Colorado in 1915. Charles W. Henderson.

Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in 1915. C. N. Gerry.

Magnesite in 1915. Charles G. Yale.

Magnesium in 1915. Frank L. Hess.

Metals and Ores in 1914 and 1915. J. P. Dunlop.

Natural Gas in 1915. John D. Northrop.

Oil Shale in Northwestern Colorado and Adjacent Areas. Dean E. Winchester.

Peat in 1915. James S. Turp.

Petroleum in 1915. John D. Northrop.

Poles Purchased, 1915. Arthur M. McCreight.

Stone in 1915. G. F. Loughlin.

Some Public and Economic Aspects of the Lumber Industry. William B. Greeley.

True Mahogany. C. D. Mell.

Water-Supply Papers 361, 380.

Western Yellow Pine in Oregon.

Width of Wagon Tires Recommended for Loads of Varying Magnitudes on Earth and Gravel Roads. E. B. McCormick.

State Reports.

Maine. Report of State Board of Health for 1914 and 1915.

Massachusetts. Report of Special Commission Appointed to Consider Financial Condition of Boston Elevated Railway Company, 1917. Gift of G. F. Swain.

Municipal Reports.

Binghamton, N. Y. Annual Report of Water Commissioners for 1915.

Chicago, Ill. Unification of Local Governments in Chicago, 1917.

Danbury, Conn. Annual Reports for 1915.

Everett, Mass. Report of Property Assessment Commission, 1916.

Hartford, Conn. Annual Report of Water Commissioners for 1915–16.

New York, N. Y. Annual Report of Department of Water Supply, Gas, and Electricity for 1915; Report of Delos F. Wilcox, Deputy Commissioner, to Department of Water Supply, Gas, and Electricity in Relation to Citizens Water Supply Company of Newtown, 1916.

Miscellaneous.

Canada, Department of Mines: Summary Report of Mines Branch for 1915.

Colorado Agricultural College Experiment Station: Comparative Bacteriological Study of Water Supply of City and County of Denver, Colorado. Walter G. Sackett.

National Board of Fire Underwriters: Reports and bulletins on the following cities: Altoona, Pa.; Augusta, Ga.; Boston, Mass.; Brockton, Mass.; Buffalo, N. Y.; Cambridge, Mass.; Cleveland, O.; Fall River, Mass.; Fitchburg, Mass.; Gloucester, Mass.; Hartford, Conn.; Haverhill, Mass.; Holyoke, Mass.; Lawrence, Mass.; Malden, Mass.; Manchester, N. H.; Muskogee, Okla.; New Bedford, Mass.; New Britain, Conn.; New Orleans, La.; North Tonawanda, N. Y.; Oklahoma City,

Okla.; Passaic, N. J.; Pittsfield, Mass.; St. John, N. B.; Salem, Mass.; Somerville, Mass.; Shreveport, La.; Taunton, Mass.; Tonawanda, N. Y.; Waltham, Mass.; Tulsa, Okla.; Washington, D. C.; White Plains, N. Y.

Duplicates for free distribution to members will be found this month, as usual, on the ends of the reading-room tables.

Attention is called to the fact that all duplicates offered to members are plainly marked as such, and that a list of them is placed on the top of the pile. It has been found that publications not duplicates, when left on the tables by readers, sometimes stray into the pile and are mistaken for duplicates. Members are therefore requested not to take for their own files any publication that does not appear on the list referred to above, without first consulting the Assistant Librarian.

The list for this month is as follows:

Baltimore, Md.: Report of Sewerage Commission, 1897.

Boston, Mass.: Annual Reports of City Engineer for 1876 and 1881; Annual Reports of Park Commissioners for 1876, 1877 (2 copies), 1879–82; Second Report of Park Commissioners, 1876; Fourth Report of Park Commissioners, 1876 (3 copies); Sixth Report of Park Commissioners, 1877 (2 copies); Parks for the People — Proceedings of Public Meeting at Faneuil Hall, 1876; Map of Back Bay Park, 1877; Proposed West Roxbury Park, 1879; Proposed Arboretum at West Roxbury, 1880; Notes on Plan of Franklin Park, 1880 (2 copies); Report on Present System of Sewerage, 1873; Sewerage of Boston, 1876 (3 copies); Report of Joint Special Committee on Improved Sewerage, 1877; Annual Report of Mystic Water Board for 1875; Annual Report of Boston Water Board for 1881; Annual Report of Water-Supply Department for 1893 (3 copies); Annual Report of Water Department for 1895; Report on Introducing Pure Water into City of Boston, 1834; Report on Plan for Supplying City of Boston with Pure Water, 1837; Report on Material for Distribution Water Pipes, 1848; Report of Joint Standing Committee on Additional Water Supply, 1874; Report of Cochituate Water Board on Mystic Water, 1874; Report of Medical Commission on Sanitary Qualities of Sudbury, Mystic,

Shawshine, and Charles River Waters; Report of Commissioners on Investigation of Water Supply, 1883; Report of Commission on Annexation of Certain Neighboring Cities and Towns, 1873; Report on Nomenclature of Streets, 1879; Digest of Statutes relating to Inspection and Construction of Buildings, 1886.

Gloucester, Mass.: First Annual Report of Water Commissioners, 1896.

Holyoke, Mass.: Annual Reports of Water Board for 1895, 1897–1899, 1902; Hearings in Case of Holyoke Water Power Company *v.* City of Holyoke, Vol. XVI (2 copies).

Industrial Arts Index, February–October, 1916.

Leicester, Mass.: Annual Reports of Water Commissioners for 1888–1891.

Lowell, Mass.: Annual Reports of Water Commissioners for 1872 and of Water Board for 1874, 1888–1910; Report of Joint Special Committee on Supply of Water, 1869.

Lynn, Mass.: Annual Reports of Water Board for 1872–1873, 1897–1898, 1900–1906, 1909–1910.

Massachusetts, Highway Commission: Annual Reports for 1896, 1898, 1899.

Massachusetts, Topographical Survey Commissioners: Annual Reports for 1897–1900.

New York, N. Y.: Aqueduct Commission Reports on New Croton Aqueduct, 1883–1887.

Newton, Mass.: Annual Reports of City Engineer for 1892, 1893, 1899, 1900, 1904–1908; Hearing on Method of Sewer Assessments, 1891 (3 copies); Annual Report of Water Board for 1886.

Pawtucket, R. I.: Quarterly Reports of Water Commissioners for June–December, 1877.

Portland, Me.: Report of Committee on Water District, 1903.

Somerville, Mass.: Annual Reports of City Engineer for 1903, 1905, 1907; Annual Reports of Mystic Water Board for 1886, 1888–1894, 1897, and of Water Commissioners for 1898, 1901, 1905, 1906.

Taunton, Mass.: Annual Report of Water Board for 1911.

Wellesley, Mass.: First Report of Water Department, 1885; Annual Reports of Water Department for 1897, 1899, 1901, and of Water and Municipal Light Board for 1903, 1904.

Wilmington, Del.: Annual Reports of Water Commissioners for 1904, 1906, 1907, (1907–08)–(1909–10), 1911–12, 1912–13.

Worcester, Mass.: Annual Reports of Water Department and City Engineer for 1878, 1881–1882, 1887, 1889–1899, 1901, 1908; Report of Committee on Additional Supply of Water, 1877; Annual Reports of Superintendent of Sewers for 1902, 1903; Worcester Sewage and Blackstone River, 1882.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the 1st of each month.)

Commonwealth of Massachusetts. — METROPOLITAN PARK COMMISSION. — *Old Colony Parkway.* — Bids will be received February 26, 1917, for construction of Neponset Bridge.

BOSTON TRANSIT COMMISSION. — *Dorchester Tunnel* has been practically completed from its beginning at Tremont St. to a point under Dorchester Ave. near Broadway in South Boston.

Work is progressing on the Broadway Station, which extends in Dorchester Ave. from Broadway to West Fourth St. The T. A. Gillespie Co. is the contractor.

Work on Section G, which extends in Dorchester Ave. from West Fourth St. to Old Colony Ave., is substantially completed north of the N. Y., N. H. & H. R. R. Co. cut, except the resurfacing of the street. Work at and south of the railroad cut is now in progress. Coleman Brothers are the contractors.

Section H and Section H Extension, which are completed, extend in Dorchester Ave. from Old Colony Ave. to near Dexter St.

The next section, Section J, extending from a point near Dexter St. in a southerly direction in and near Dorchester Ave. and Boston St. to a little south of Ralston St., and embracing the station in Andrew Sq., is being constructed. The work is about three fourths done, the work remaining being in Boston St. and in the station south of Dexter St. The T. A. Gillespie Co. is the contractor.

City of Boston. — Public Works Department. — Highway Division, Paving Service.

Caledonian Ave.,	Spring St., southerly.	Grading.
Hubert St.,	Shawmut Ave. to Westminster St.	Grading.
Ralston St.,	Dorchester Ave. to Old Colony Ave.	Grading.

Public Works Department, Bridge and Ferry Division. — *Strandway Improvement.* — The New York State Dredging Corporation has started work on the Strandway Improvement, South Boston.

This work involves the extension of the concrete sewer outlets at H, Vale, and Kemp streets and Crescent Ave.; the construction of a wooden bulkhead 1 700 ft. long, extending easterly from a point near Columbia Road Bridge into Old Harbor; reclamation of some seventy-five acres of flat land on the shores adjacent to Old Harbor by hydraulic fill; the construction of a fifty-six acre playground, surrounded by suitable drives and walks; and the construction of a new concrete bathhouse near McKenzie Beach capable of bathing four thousand people per day.

In spite of very unfavorable weather and ice conditions, all the sewer work has been started, and the bulkhead about seventy-five per cent. completed.

New York, New Haven & Hartford R. R. Co. — *Boston Mass., Southampton Street Engine Facilities.* — Work consists of new 39-stall engine house, 95 ft. turntable, ash pits, boiler house, office building, water tank and necessary trackage.

During past month, completed excavating for engine house, office building and ash pits; completed driving concrete piles

for engine house and office building and progressing on driving of concrete piles for ash pits and pouring of concrete foundation for engine house.

Fore River Shipbuilding Corporation, Quincy, Mass., has the following work in progress:

Eight torpedo boat destroyers for the United States Government.

Twenty-seven submarines for the United States Government.

Two oil tankers for the Texas Company.

Two oil tankers for the Mexican Petroleum Company.

One oil tanker for the Argentine Government.

Three freight steamers for the Luckenbach Company, Inc.

Two general cargo vessels for the Cunard Steamship Company.

Vol. IV APRIL, 1917 No. 4

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, APRIL 18, 1917,

at 8 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Charles R. Gow will read a paper entitled, "The History and Present Status of the Concrete Pile Industry." The paper will be illustrated with lantern slides.

The Boston sections of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers have been invited to join in the meeting.

S. E. TINKHAM, *Secretary.*

SPECIAL MEETING.

Military Night.

A special meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY EVENING, APRIL 11, 1917,

at 7.30 o'clock in LORIMER HALL, TREMONT TEMPLE, BOSTON. (The main entrance, 82 Tremont Street, will be found the most convenient.)

The meeting will be addressed by the following speakers:

Lieut.-Col. W. P. Chamberlain, Medical Corps, U. S. A., on Military Sanitation.

Capt. F. B. Downing, Corps of Engineers, U. S. A., on Organization and Duties of Engineer Troops.

Capt. John F. Osborn, First Corps of Cadets, Mass. National Guard, on the Engineering Instruction now being given in that Corps.

The addresses will be illustrated with lantern slides.

Resolutions will be presented looking to the organization of a corps of engineers as a part of the National Guard of the State of Massachusetts, and also to the organization of a sanitary reserve.

S. E. TINKHAM, *Secretary.*

ANNOUNCEMENT.

An Engineer Regiment for the National Guard.

A regiment of engineers for the Fifth Division of the National Guard (New England) is now being raised by the First Corps Cadets of Boston, an organization which has been in continuous existence since 1741.

The expansion of this corps from a battalion of four companies of infantry to a regiment of six companies of engineers, with the necessary staff and non-commissioned staff, will give opportunity to a large number of engineers to become officers and non-commissioned officers in an organization which promises to become the *corps d'élite* of the National Guard. Twenty officers beside those already in the Corps will be necessary, and a large number of trained enlisted men will be required to bring the new organization up to war strength.

The plan is approved by the Governor, the Adjutant-General and the Militia Bureau, and the two ranking officers of the new regiment will be regular army officers, thus giving promise that the regiment will be given a chance for real service.

This organization will be the first and only engineer regiment in New England, and will be the only complete National Guard engineer regiment in the United States outside of that of New York.

Work with this organization will give the very best opportunity to learn all branches of the military service and thus give

the enlisted men a chance to study for commissions in other branches.

The ranks of the new organization are filling up fast, and there is need for prompt action by those wishing to become identified with the new regiment. Information will be gladly furnished at the armory any day or evening, or on application to Capt. John F. Osborn, 201 Devonshire Street. Regular drills are held every Tuesday evening, and some engineer work is now being done.

What better time can there be for the engineers of Boston to show that they are ready for action, and what organization can better serve as a medium for doing their best work than this new regiment?

The requirements for an officer of engineers can be obtained on application. The following are some of the professions and trades needed for a flexible unit:

ENGINEERS.

Civil	Mining	Bridge
Mechanical	Sanitary	Road
Electrical	Hydraulic	Railroad

TRADES.

Construction foreman	Carpenter	Hoisting engineer
Surveyor	Blacksmith	Locomotive engineer
Photographer	Plumber	Locomotive fireman
Draftsman	Mason	Teamster
Master mechanic	Saddler	Blaster
Dock builder	Horseshoer	Shorer
Telegrapher	Wheelwright	Woodsman
Lineman	Concrete worker	Iron worker
Electrician	Machinist	Timberman
Pipe fitter	Rigger	

PAPERS IN THIS NUMBER.

"The History and Present Status of the Concrete Pile Industry." Charles R. Gow.

Memoir of deceased member.

Current Discussions.

Paper.	Author.	Published.	Discussion Closes.
"Manchester, Mass., Outfall Sewer."	Raymond C. Allen.	Mar.	May 10.
"Extension of the North Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor."	Clarence A. Moore.	Mar.	May 10.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

Boston, Mass., March 21, 1917. — The sixty-ninth annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, at 12.15 o'clock P.M., President Richard A. Hale in the chair.

The reading of the record of the last meeting was dispensed with, and it was approved as printed in the March Journal.

The President reported for the Board of Government the election of the following candidates for membership in the grades named:

Member — Mr. Harold Simpson Crocker.
Juniors — Messrs. Waldo Francis Pike and Henry Connor Sheils.

The Secretary announced the deaths of members of the Society as follows:

William J. C. Semple, died November 10, 1916; Harry C. Foster, died March 5, 1917; Willard W. Wight, died March 10, 1917;

and by vote the President was requested to appoint committees to prepare memoirs.

The committees appointed are: On memoir of Harry C.

Foster, Mr. Frank O. Whitney; on memoir of William J. C. Semple, Mr. Franklin M. Miner; and on memoir of Willard W. Wight, Mr. John J. Van Valkenburgh.

The Secretary presented, for Mr. L. Lee Street, — the committee appointed for the purpose, — the memoir of Lorenzo G. Moulton, which he had prepared. By vote it was accepted and ordered printed in the JOURNAL of the Society.

The annual reports were then presented as follows: The report of the Board of Government was read by the Secretary and by vote was accepted and placed on file.

The Treasurer read his annual report which was accepted and placed on file.

The Secretary read his annual report which was also accepted and placed on file.

The Librarian read the annual report of the Committee on the Library which was accepted and placed on file.

Mr. Henry A. Symonds read the report of the Committee on Social Activities which was accepted and placed on file.

By vote, the appointment of the special committees of the Society was referred to the Board of Government, with full powers.

The tellers of election, Messrs. Nathan S. Brock and Henry B. Wood, submitted the result of the letter ballot for officers of the Society for the ensuing year, and in accordance with their report the President announced that the following officers had been elected:

President — George C. Whipple.

Vice-President (for two years) — Charles W. Sherman.

Secretary — S. Everett Tinkham.

Treasurer — Frank O. Whitney.

Directors (for two years) — Clarence T. Fernald and Lewis E. Moore.

The retiring President, Mr. Richard A. Hale, then delivered the annual address which will be printed in the next number of the JOURNAL.

Mr. Frank A. Marston, one of the committee to recommend the award of the Desmond FitzGerald Medal, at the request of the President, then presented that medal for the year 1916 to

Mr. Dana Melvin Wood, for his paper entitled, "Power Estimates from Stream Flow and Rainfall Data." Mr. Wood in accepting the medal thanked the Society for the honor accorded him in presenting him with this beautiful medal.

Past President Eddy suggested that, in connection with the proposed State Constitutional Convention to be held this year, it might be well to have matters relating to engineering properly presented to that Convention.

He moved, and it was so voted: That matters in relation to engineering coming before the Constitutional Convention, to be held this year, be referred to the Board of Government with power to act.

The meeting then adjourned to partake of the thirty-fifth annual dinner.

During the dinner there was singing by Joseph Ecker.

Before introducing the speaker of the afternoon, the President presented the President-elect, Mr. George C. Whipple.

Mr. Whipple expressed his sincere thanks for the honor which had been conferred upon him, and promised his most earnest endeavors, with the assistance of the other officers who had been elected, to promote the welfare of the Society and the success of the meetings.

Mr. Frank M. Williams, state engineer of New York, was then introduced and gave a most interesting account of the construction of the New York Barge Canal and Terminal Connections. Mr. Williams's address was illustrated with a large number of beautifully colored lantern slides showing the progress of the work, and with motion pictures of the operation of the locks.

On motion of Mr. Eddy, a unanimous vote of thanks was tendered Mr. Williams for his kindness in coming before the Society with his interesting and instructive address. The meeting then adjourned.

In the evening, the "Smoker" was held in the auditorium, the attendance being 325. Light refreshments were served as usual.

A most interesting and enjoyable entertainment was furnished by the White Entertainment Bureau, introducing The

Oxley Troubadours, two Buck and Wing Dancers, Mr. Simmons, entertainer, Mr. Blood, "The Man with the Hat," and Mr. Myer, tenor soloist.

The attendance of members and guests at the various functions of the annual meeting was more than 360.

S. E. TINKHAM, *Secretary.*

ANNUAL MEETING OF THE SANITARY SECTION.

BOSTON, MASS., March 7, 1917. — The annual meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in Chipman Hall, Tremont Temple. The meeting was called to order at 7.45 o'clock by Vice-Chairman Edward Wright, Jr.

The minutes of the February meeting were read and approved.

The appointment of the committee to study, collect data and report upon the distribution of excessive rainfall in Boston and vicinity was announced as follows: John W. Howard, Edgar S. Dorr, Lewis M. Hastings, Henry A. Varney, Edwin H. Rogers, William L. Vennard, Frank A. Marston.

The annual report of the Executive Committee was read by the Clerk.

Voted that the report of the Executive Committee be accepted and placed on file.

Voted that the recommendation of the Executive Committee be adopted as follows:

That the Board of Government of the Society be requested to consider the advisability of, and if possible bring about the installation of, mechanical ventilating apparatus in the Library, in order that the Section meetings may be held in that room with greater comfort. Also, that a more satisfactory screen be installed for use with the lantern.

A verbal report of progress of the Committee on Sewer Assessments was made by H. P. Eddy.

The informal report of the Nominating Committee was presented by the chairman of the committee, E. M. Blake. There were no other nominations.

Voted that Mr. Blake be instructed to cast one ballot for the officers and committee as nominated, whereupon the following were declared elected for the ensuing year.

Chairman — Frank A. Marston.
Vice-Chairman — Frank B. Sanborn.
Clerk — Arthur D. Weston.

Additional members of the Executive Committee:

Walter S. McKenzie.
Henry T. Stiff.
Henry A. Varney.

The speaker of the evening was then introduced, Mr. George W. Fuller, consulting engineer, of New York, who gave an interesting discussion on the question, "What Shall Be the Limitation in the Pollution of Raw Waters so that They May Be Safely Purified by Modern Water Treatment Plants?"

The subject was further discussed by Messrs. H. P. Eddy, Robert Spurr Weston and Stephen DeM. Gage.

Voted to extend to Mr. Fuller the appreciation of the Section for his interesting talk.

There were 45 present. Meeting adjourned about 9.30 o'clock.

Frank A. Marston, *Clerk.*

ANNUAL REPORTS.

Report of the Board of Government for the Year 1916-1917.

Boston, Mass., March 21, 1917.

To the Boston Society of Civil Engineers:

Pursuant to the requirements of the Constitution, the Board of Government presents its report for the year ending March 21, 1917.

The total membership of the Society a year ago was 999, of whom 875 were members, 83 juniors, 6 honorary members, 26 associates and 9 were members of the Sanitary Section only.

The total loss in membership during the year has been 70, of whom 23 resigned, 31 forfeited membership on account of non-payment of dues, and 16 have died.

There has been added to the Society during the year a total of 37 members of all grades; 36 have been elected and completed their membership, 1 has been reinstated, 6 juniors have been transferred to the grade of member.

Five applicants have been elected but have not completed their membership, and there are 9 applicants now before the Board for action.

The present membership of the Society consists of 5 honorary members, 846 members, 77 juniors, 30 associates and 8 members of the Sanitary Section only, making a total membership of 966.

The loss by death during the year is 16. The record is as follows:

William Thomas Shaw, died February 26, 1916.
Edward Davis Bolton, died March 10, 1916.
Erasmus Darwin Leavitt, honorary member, died March 11, 1916.
Charles Wilson Ross, died April 11, 1916.
Elmer Lawrence Corthell, died May 16, 1916.
Frank Edson Shedd, died September 22, 1916.
John Waldo Ellis, died October 30, 1916.
William Cooper Cuntz, died November 2, 1916.
William J. C. Semple, died November 16, 1916.
William Henry Jaques, died November 23, 1916.
Harold Parker, died November 29, 1916.
Edmund Brownell Weston, died December 9, 1916.
Walter Nathan Charles, died January 20, 1917.
Alfred Wright Parker, died February 24, 1917.
Harry C. Foster, died March 5, 1917.
Willard Wendell Wight, died March 10, 1917.

Under authority of By-Law 8, the Board of Government, for reasons which it deems sufficient, has remitted the dues of ten members of the Society.

Twelve meetings have been held during the year, ten regular and two special. The average attendance at the regular and special meetings was 128+, the largest being 375 and the smallest 13. (The special meeting at which the attendance was so small was held in the Society's Library, and was devoted to a discussion of the metric system of weights and measures.)

The following papers and addresses have been given:

March 15, 1916. — Address of Retiring President Charles R. Gow. Lecture by Dr. Charles H. Tyndale, "The Wonders of Ether Waves and Radium Mysteries." (Illustrated.)

April 21, 1916. — Address by Dr. Alexander C. Humphreys, president Stevens Institute of Technology, "Reform and Regulation."

April 27, 1916. — (Special.) Discussion, "Practical Steps Remaining to be Taken in Completing the Abandonment of Ancient, Customary Units by the Substitution of the Metric System of Weights and Measures."

May 17, 1916. — Mr. Thomas C. Atwood, "The Construction of the Yale Bowl." (Illustrated.)

June 21, 1916. — Address by Rear-Admiral Robert E. Peary, on "National Preparedness."

September 20, 1916. — Mr. Eugene E. Pettee, "The Construction of the Portland Bridge." (Illustrated.)

October 18, 1916. — Mr. H. Whittemore Brown, "The Groined Arch as a Means of Concrete Floor Construction." (Illustrated.)

November 17, 1916. — Mr. Nathan C. Grover, "Effect of Channel on Stream Flow." (Illustrated.)

December 20, 1916. — Mr. Arthur E. Morgan, president of the Morgan Engineering Company, "Flood Control in Miami Valley." (Illustrated.)

January 10, 1917. — (Special.) Mr. Jacob Lowenstein, of the American

Bridge Company, "The Construction and Erection of Hell Gate Bridge." (Illustrated.)

January 24, 1917. — Past-President Desmond FitzGerald, illustrated talk on his travels.

February 21, 1917. — Past-President James W. Rollins, "The New Boston Dry Dock." (Illustrated.)

The Sanitary Section has held nine meetings with an average attendance of 51. The following papers have been presented at the meetings of the Section:

March 1, 1916. — "Eight Months' Experience in Servia with the American Sanitary Commission," by Stanley H. Osborn, M.D., state district health officer for the Berkshire District, Mass.

April 5, 1916. — Preliminary report of committee and discussion of "Methods of Design and Construction and Results of Operation of Inverted Siphons for Carrying Sewage Only and for Storm Water."

May 3, 1916. — "Sanitary and Hydraulic Work in the Hawaiian Islands," by Arthur R. Keller, professor of civil engineering in the Hawaiian College.

June 7, 1916. — "The Sewage Disposal Problem Confronting the City of Philadelphia," by W. L. Stevenson, assistant engineer in charge, Sewage Disposal, Philadelphia.

November 1, 1916. — Discussion on "Catch Basin Construction and Maintenance," opened by George A. Carpenter.

December 6, 1916. — "How Texas is Protecting the Public Health," by Charles Saville, director of the public health of the city of Dallas, Texas.

December 27, 1916. — "The Agua Clara Filtration Plant at Gatun, C. Z.," by Theodore R. Kendall.

January 3, 1917. — "Outfall Sewer and Pumping Station, Manchester, Mass.," by Raymond C. Allen; "Extension of the Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor," by Clarence A. Moore, assistant engineer, Metropolitan Water and Sewerage Board.

February 7, 1917. — "Sewage Disposal in Rhode Island," by Stephen DeM. Gage.

The joint Engineering Dinner was held at the Boston City Club, on February 7, 1917, under the direction of a committee representing this Society, the local section of the American Society of Mechanical Engineers and that of the American Institute of Electrical Engineers, the latter society taking the more active part in the management this year. The attendance was 451.

The Board of Government has adopted the recommendation of the Committee appointed to award the Desmond FitzGerald medal, and announces that it will be presented this year to Dana M. Wood, for the paper entitled, "Power Estimates from Stream Flow and Rainfall Data," which was published in the JOURNAL of the Society for March, 1916.

The report of the Editor of the JOURNAL for the calendar year 1916, which is submitted for publication with the reports of the other officers of the Society, shows that a total of 859 pages were printed in the ten issues, with 86 cuts and 21 insert plates, at a gross cost of $3 508.24. The net cost after deducting sum received for advertisements, sales of JOURNALS, etc., was $1 883.81. The increase in net cost over 1915 is due to the larger number of pages and of illustrations and a very considerable increase in the cost of paper.

Owing to the desire of our tenants for increased space, a lease was taken of the southerly room, adjoining the room of the Hersey Manufacturing Company, at an annual expense of $450. The Hersey Manufacturing Company and the New England Water Works Association pay $300 of this amount. Our Society, with this additional expense of $150, has the advantage of the entire occupancy of the front room, and much needed additional space for library accommodations.

The Legislative Committee which was first appointed by the Board of Government two years ago was continued, and has shown its usefulness in the work during the past year. The committee has kept informed of various legislative bills that appeared to be of special interest to engineers in connection with municipalities, public welfare, conservation, etc., and a general notice was usually given to members whom it was considered might be specially interested, with the result of representation of members at the hearing.

At the February, 1917, meeting, the Society, by vote, tendered its services to the Committee on Public Safety appointed by the Governor of the Commonwealth, to study out and report on the various phases of the preparedness movement.

A committee of the Society has also been appointed to collect, compile and analyze, and to report upon the best figures of run-off in New England which are available for water-power purposes. This committee has begun its work, and it is expected that much valuable data will be gathered.

There has been added to the Permanent Fund during the year $2 412.48. The present value of the fund is now $39 888.17, and with the E. K. Turner Fund makes the total amount of the permanent funds of the Society $40 886.04, an increase during the year of $2 410.35.

From the Treasurer's report it appears that the revenue for the year applicable to current expenses has been $9 979.61, an excess of expenditures over receipts of $621.50. The present cash balance on hand in the current fund is $573.33.

The Committee on Social Activities, under the direction of its new chairman, Mr. Henry A. Symonds, has continued the practice of arranging an informal dinner to immediately precede the regular meeting of the Society, and, while the attendance has not been as large as in some years, it has been sufficient to show that there is a desire among a number of the members for a gathering of this nature. The report of this committee gives in detail the entertainments which have been provided.

At the January meeting of the Board, the Editor of the JOURNAL, Mr. Edward C. Sherman, tendered his resignation of that position because of removal from Boston. The Board regrets that it was obliged to accept this resignation, as it feels that the success which has attended the publication of our JOURNAL during the three years of its existence is largely due to his efficient services. The position has been filled by the election of Mr. William L. Butcher.

For the Board of Government,

RICHARD A. HALE, *President.*

Report of the Treasurer.

Boston, March 1, 1917.

To the Boston Society of Civil Engineers:

Your Treasurer presents the following report for the year 1916–17:

Detailed data are contained in the appended tabular statements. Table 1 gives the receipts and expenditures for the year; Table 2, comparative balance sheets; and Table 3, investment of the permanent funds.

The revenue applicable to current expenses has been $9 358.05, being $84.72 more than for the preceding year. The current expenses were $9 979.61. The amount of cash on hand is $573.33.

There has been a large increase in the expense of publishing the Journal, as may be seen by comparing the figures for the past two years, the amounts being $2 721.20 and $3 851.48 respectively.

There has been an increase in the Permanent Fund of $2 412.48, which is less than for the previous year on account of a decrease in the number of entrance fees.

The Turner Fund has been invested in a thousand dollar five per cent. bond of the American Telephone and Telegraph Company.

Respectfully submitted,

Frank O. Whitney, *Treasurer.*

Table 1. — Receipts and Expenditures.

current fund.

Receipts.

Balance from March, 1916	$1 194.89
Members' Dues	7 726.58
Advertisements	1 372.50
Sales of Journals	209.12
Library Fines	6.66
Waste Paper Sold	16.88
Interest on Bank Balances	26.31
	$10 552.94

Expenditures.

Journal	$3 851.48
Printing, Stationery, Postage and Library Supplies	1 019.89
Rent (net)	1 745.41
Light	75.90
Salaries (except Editor)	2 119.00
Reporting	70.00
Stereopticon	62.32
Books	81.70

Binding	$152.05
Periodicals	60.45
Incidentals and Repairs	354.15
Insurance	35.44
Telephone (net)	20.70
Annual Meeting and Dinner	162.40
Committee on Social Activities	85.58
Joint Engineers' Dinner	15.70
Sanitary Section, Printing, Postage and Stationery	25.25
Sanitary Section, Stereopticon	30.00
Sanitary Section, Incidentals	12.19
Cash on hand	573.33
	$10 552.94

PERMANENT FUND.

Receipts.

Cash on hand, March, 1916	$968.48
Entrance Fees	330.00
Contribution	100.00
Coöperative Banks, Matured Shares	1 007.65
Interest	1 691.54
	$4 097.67

Paid Out.

Coöperative Bank Dues	$900.00
Coöperative Banks, Shares Purchased	372.90
Vermont Power & Mfg. Co., Bond Purchased	965.00
American Tel. & Tel. Co., Bond Purchased	993.75
Cash on hand, March 1, 1917	866.02
	$4 097.67

E. K. TURNER LIBRARY FUND.

Cash on hand, March 1, 1916	$1 000.00
Suffolk Bank, Interest	8.75
	$1 008.75

Vermont Power & Mfg. Co., Bond Purchased	$993.75
Accrued Interest on Bond Paid	2.78
Books Purchased	8.10
Cash on hand, March 1, 1916	4.12
	$1 008.75

TABLE 2. — COMPARATIVE BALANCE SHEETS.

Assets.	March 18, 1914.	March 17, 1915.	March 1, 1916.	March 1, 1917.
Cash	$119.41	$1 267.73	$3 163.37	**$1 443.47**
Bonds and Notes	27 605.50	29 191.75	30 366.25	**33 318.75**
Stock	1 950.00	1 950.00	1 950.00	**1 950.00**
Coöperative Banks	3 545.72	3 212.65	4 190.96	**4 747.15**
Accounts Receivable (Rents).	145.83	145.83	......	......
Library	7 500.00	7 500.00	7 500.00	**7 500.00**
Furniture	1 325.15	1 950.49	2 405.11	**2 405.11**
	$42 191.61	$45 218.45	$49 575.69	**$51 364.48**
Liabilities:				
Permanent Fund	$31 864.29	$34 582.13	$37 475.69	**$39 888.17**
E. K. Turner Fund	......	......	1 000.00	**997.87**
Unexpended Appropriations..	851.46	613.52	......	......
Current Funds	535.71	451.31	1 194.89	**573.33**
Accounts Payable	115.00	121.00	......	......
Surplus	8 825.15	9 450.49	9 905.11	**9 905.11**
	$42 191.61	$45 218.45	$49 575.69	**$51 364.48**

TABLE 3. — INVESTMENT OF THE PERMANENT FUND, MARCH 1, 1917.

Bonds.	Par Value.	Actual Cost.	Present Market Value.	Value as Carried on Books.
American Tel. & Tel. Co. col. tr. 4%, 1929	$3 000.00	$2 328.75	$2 760.00	$2 737.50
Union Elec. Light & Power Co. 5%, 1932	2 000.00	2 050.00	1 960.00	2 050.00
Blackstone Valley Gas & Elec. Co. 5%, 1939	2 000.00	1 995.00	2 000.00	1 995.00
Dayton Gas Co. 5%, 1930.	2 000.00	2 000.00	1 960.00	2 000.00
Milford & Uxbridge St. Ry. 5%, 1918	3 000.00	2 942.50	2 970.00	2 942.50
Railway & Light Securities Co. 5%, 1939	3 000.00	3 000.00	2 910.00	3 000.00
Superior Light & Power Co. 4%, 1931	4 000.00	3 347.50	3 440.00	3 347.50
Wheeling Electric Co. 5%, 1941	4 000.00	3 845.00	3 800.00	3 845.00
Economy Light & Power Co. 5%, 1956	1 000.00	990.00	990.00	990.00
Tampa Electric Co. 5%, 1933	2 000.00	2 000.00	1 980.00	2 000.00

	Par Value.	Actual Cost.	Present Market Value.	Value as Carried on Books.
Galveston Houston Elec. Ry. Co. 5%, 1954	$2 000.00	$1 940.00	$1 860.00	$1 940.00
Northern Texas Elec. Co. 5%, 1940	2 000.00	1 932.50	1 860.00	1 932.50
Chicago & Northwestern Ry. 5%, 1987	1 000.00	1 102.50	1 160.00	1 102.50
Vermont Power & Mfg. Co. 5%, 1928	1 000.00	965.00	940.00	965.00
Am. Tel. & Tel. Co. 5%, 1946	1 000.00	993.75	1 010.00	993.75
	$33 000.00	$31 432.50	$31 600.00	$31 841.25
Note.				
Dallas Elec. Co. 5%, 1917.	500.00	483.75	490.00	483.75
Stock.				
15 shares Am. Tel. & Tel. Co.	1 500.00	1 950.00	1 875.00	1 950.00
Total Securities	$35 000.00	$33 866.25	$33 965.00	$34 275.00

Coöperative Banks.	
25 shares Merchants Coöperative Bank, including interest to March	$1 495.85
25 shares Volunteer Coöperative Bank, including interest to January	1 764.50
25 shares Watertown Coöperative Bank, including interest to March	1 486.80
	$4 747.15
Total value of Invested Funds	$39 022.15
Cash on hand	866.02
Total value of Permanent Fund	$39 888.17

	Par Value.	Actual Cost.	Present Market Value.		
E. K. Turner Fund.					
Am. Tel. & Tel. Co. 5%, 1946	$1 000.00	$993.75	$1 010.00	$993.75	
Cash on hand				4.12	
					997.87
					$40 886.04

We have examined the above report and found it correct.

ARTHUR W. DEAN,
GEORGE C. WHIPPLE,
Auditing Committee of Directors of the Boston Society of Civil Engineers.

MARCH 15, 1917.

Report of the Secretary, 1916–17.

Boston, Mass., March 21, 1917.

S. Everett Tinkham, Secretary, *in account with the* Boston Society of Civil Engineers. *Dr.*

For cash received during the year ending March 21, 1917, as follows:

From entrance fees, new members and transfers:			
24 members and associates	at $10 =	$240.00	
12 juniors	at 5 =	60.00	
6 juniors transferred to members	at 5 =	30.00	
Total from entrance fees			$330.00
From annual dues for 1916–17, including dues from new members		$7 625.08	
From back dues		22.00	
From dues for 1917–18		79.50	
Total from dues			7 726.58
From rents			1 089.59
From advertisements			1 372.50
From sale of Journals, reprints and cuts			209.12
From sale of old paper			16.88
From library fines			6.66
From contribution to building fund			100.00
Total			$10 851.33

The above amount has been paid to the Treasurer, whose receipts the Secretary holds.

We have examined the above report and found it correct.

George C. Whipple,
Arthur W. Dean,
Auditing Committee of Directors of the Boston Society of Civil Engineers.

Report of Library Committee, 1916–17.

Boston, Mass., March 21, 1917.

To the Boston Society of Civil Engineers:

The Library Committee submits the following report for the year 1916–17:

Since the last report 475 volumes bound in cloth and 532 bound in paper have been added to the library, making a total of 1 007 accessions.

There are now 9 177 cloth-bound volumes in the library, including such

duplicates from the Edmund K. Turner bequest as have not been disposed of, and the volumes bound in paper number about 2 700.

During the year 386 books have been loaned to members, and fines to the amount of $6.66 have been collected. It would seem, therefore, that reducing the time during which a book may be kept out, from five weeks to two, has not resulted in a greater number of books being kept out over time, and it has certainly afforded to a greater number of our members an opportunity to use the books, which seems to your committee a fairer arrangement all around, and especially in the case of those books which are most in demand.

The usual amount of binding has been done, and to the list of periodicals to be bound regularly have been added *Good Roads*, *The American City*, *Power*, the *Bulletin* of the General Contractors Association and the *American Journal of Public Health*. For our subscription to the last mentioned of these we are indebted to Mr. Harrison P. Eddy.

Of the sixteen new engineering books added to Section 10, one, "The American Road," was presented to the library by its author, Prof. James I. Tucker, of the University of Oklahoma, and the remaining fifteen were purchased. Of these fifteen, two, on railroad engineering, were purchased from the income of the Turner Fund. The choice of subject was suggested by Mr. Turner's well-known interest in railroad engineering.

A revolving bookcase, the gift of Mr. Frank A. Barbour, has been added to the furnishings of the library. A sectional oak cabinet has also been installed in the reading-room by the Catalogue Equipment and Supply Company, and contains its collection of trade catalogues known as "Catalogue Studies," described in the December, 1916, issue of the JOURNAL.

During the year there have been received from members several miscellaneous donations of reports, periodicals, etc. Donations of this sort and the interest which prompts them are greatly appreciated. While they contain a great many duplicates which must be sorted out and disposed of, there often remain, after these have been weeded out, a considerable number of copies needed for the completion of the Society's files.

The increasing number of duplicates which seemed too valuable to throw away has led to the establishment of a practice which seems to be appreciated by our members. Beginning with September, 1916, a list of duplicates for free distribution to members has appeared each month in the Society's JOURNAL. The committee is pleased to note that the greater part of these duplicates have proved acceptable to the members, and the practice will be continued. It will not be possible, of course, to publish a list every month, but a list will appear as often as the number and character of the duplicates on hand warrant it.

The work of completing files of reports and magazines, indexing, rearranging, etc., is being continued with good results, though it has been more or less impeded by lack of space, the extra shelf and storage room afforded by the enlargement of the Society's quarters not having been available until this week. The remainder of Section 1, Society Publications, and the whole of

Section 2, Periodicals, have been catalogued, and to the card index of papers read before the Society have been added author, subject and, in cases where it seemed advisable, title cards for all papers read before the Sanitary Section.

Respectfully submitted,

S. E. Tinkham,
Frederic I. Winslow,
Henry F. Bryant,
Committee on Library.

Report of the Executive Committee of the Sanitary Section.

Boston, Mass., March 7, 1917.

To the Sanitary Section, Boston Society of Civil Engineers:

The program for the past year has included nine meetings, the subjects and speakers being as follows:

March 1, 1916. — "Eight Months' Experiences in Servia with the American Sanitary Commission," by Stanley H. Osborn, M.D., state district health officer for the Berkshire District, Mass.

April 5, 1916. — Preliminary report of committee and discussion of "Methods of Design and Construction and Results of Operation of Inverted Siphons for Carrying Sewage Only and for Storm Water."

May 3, 1916. — "Sanitary and Hydraulic Work in the Hawaiian Islands," by Arthur R. Keller, professor of civil engineering in the Hawaiian College.

June 7, 1916. — "The Sewage Disposal Problem Confronting the City of Philadelphia," by W. L. Stevenson, assistant engineer in charge, Sewage Disposal, Philadelphia.

November 1, 1916. — Discussion on "Catch Basin Construction and Maintenance," opened by George A. Carpenter.

December 6, 1916. — "How Texas is Protecting the Public Health," by Charles Saville, director of public health of the city of Dallas, Tex.

December 27, 1916. — "The Agua Clara Filtration Plant at Gatun, C. Z.," by Theodore R. Kendall.

January 3, 1917. — "Outfall Sewer and Pumping Station, Manchester, Mass.," by Raymond C. Allen; "Extension of the Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor," by Clarence A. Moore, assistant engineer, Metropolitan Water and Sewerage Board.

February 7, 1917. — "Sewage Disposal in Rhode Island," by Stephen DeM. Gage.

It is interesting to note that five of the list of speakers are from outside the membership of the Society. Lantern slides were used at all except one meeting. Much of the material has been published in the Journal, and there still remains the report of the Committee on Inverted Siphons, which it is hoped will be available for publishing soon.

One meeting was held at the Engineers' Club, six in the Society Library, and two in Chipman Hall. The records seem to indicate that there is but little to be gained by holding the meetings in Chipman Hall, and that, if some method of mechanical ventilation could be installed in the Library, that room would be preferable as a meeting place for the Sanitary Section. The expense

would be somewhat less. If the meetings are held regularly in the Library, a more satisfactory screen could be installed, in order that satisfactory results may be obtained in using the lantern.

The Executive Committee deemed it best to omit dinners in connection with the meetings, largely because of the increased cost.

March 1, 1916 (annual meeting)	65
April 5, 1916	54
May 3, 1916	37
June 7, 1916	46
November 1, 1916	60
December 6, 1916	61
December 27, 1916	29
January 3, 1917	64
February 7, 1917	42
Average	51

The total membership of the Section is 184, of whom 1 is an honorary member, 8 are members of the Sanitary Section only, 8 are juniors and 1 an associate.

During the past year the Section has authorized the appointment of one special committee, — that on the distribution of excessive rainfall in Boston and vicinity. There are three other special committees in service.

It is recommended: That the Board of Government of the Society be requested to consider the advisability of and if possible bring about the installation of mechanical ventilating apparatus in the Library, in order that the Section meetings may be held in that room with greater comfort. Also, that a more satisfactory screen be installed for use with the lantern.

Respectfully submitted for the Executive Committee,

Frank A. Marston, *Clerk.*

Report of the Committee on Social Activities.

Boston, Mass., March 21, 1917.

To the Boston Society of Civil Engineers:

The Committee on Social Activities presents the following brief outline of the work during the past year:

The committee has participated in the preparation for entertainments; for the joint outing with the New England Water Works Association held last June, at Pemberton; four dinners at the City Club, and the Ladies' Night.

The attendance at the June meeting was very satisfactory, and we believe the outing to have been a thorough success, and recommend its continuance.

The talk by Rear-Admiral Peary was greatly enjoyed by the members and guests.

We regret to state that the ball game was won by the New England Water Works Association team.

An informal dinner at the City Club was held on October 17, with an attendance of 29. The entertainment was furnished by Wendell Mason, a reader and entertainer of large reputation. The toastmaster on this occasion was Edmund M. Blake — no further comments necessary.

The second informal dinner at the City Club was held on November 15, with an attendance of 63. We were then given a remarkable word picture of the British campaign at Gallipoli by John Gallishaw, a Harvard senior. Past President Gow did the honors and threw in some of his good stories.

The third informal dinner at the City Club was held December 20, with an attendance of 27. Through the efforts of Dean Burton, of the Massachusetts Institute of Technology, the M. I. T. vocal quartet and a quartet from the Banjo Club accepted an invitation to the dinner, and gave a delightful entertainment. Edward C. Sherman acted as toastmaster, and greatly helped the entertainment along by his good stories and timely hits. Messrs. Blake and Eddy told some good stories, and Mr. Arthur E. Morgan, the speaker at the regular meeting of the Society, gave an interesting informal talk.

Ladies' Night was held in Chipman Hall, January 24, with an attendance of 88. It is almost superfluous to add to the expressions of gratitude to Mr. Desmond FitzGerald for his kindness in presenting a section of his wonderful travel pictures, as one more of the innumerable acts by Mr. FitzGerald in the interests of the Society and for the pleasures of its members. Music was furnished for the evening by an amateur orchestra from the Newton High School, led by Allen Symonds.

The last informal dinner of the Society year was held on February 21, with an attendance of 54, David A. Ambrose very ably presiding. Samuel J. Simmons, a veteran of the Civil War, who passed through some of the hottest engagements of that conflict, vividly described some of his experiences.

The chairman wishes to express his appreciation of the assistance given by the other members of the Committee on Social Activities, who have always held themselves ready to take a hand, and give their best efforts towards making the meetings a success.

It is perhaps proper at this time for the chairman of this committee to mention briefly one or two points with which the present committee have had to deal, and with which future committees must contend.

It is generally understood to be the principal function of the Committee on Social Activities to provide such features as will promote the interests of the regular meetings, enlarge the attendance, and increase the enjoyment of all who attend.

The general plan, originated by the first Committee on Social Activities, seemed to work very successfully in the past in arousing interest in the Society, and in bringing out a good attendance.

It is true that in many cases the attendance at the dinner exceeded that at the regular meetings, and it was found that only a fraction of those attending the dinners stayed for the regular meetings.. In this respect the exact purpose was not carried out, but we believe a great good was accomplished by the social intercourse brought about through these dinners.

We must acknowledge the falling off in attendance at the dinners during the last year, and, to face the causes frankly, we believe it due to three reasons.

It would be dodging the issue not to admit the wonderful ability and power of Chairman Blake of the past committees to arouse enthusiasm and interest in these dinners. More missionary work was done during the former years than has been practicable by the present committee, in efforts to bring out large attendance.

The increased cost of everything has compelled the City Club to advance its prices for dinners of this class.

Another important cause is probably the fact that the informal dinners are getting to be somewhat of an old story.

Fully realizing the handicap of these conditions, the Committee on Social Activities has canvassed the field in an effort to provide a different form of entertainment to break up the monotony, and to obtain better rates, but have been unable to strike a combination which seemed to fill the needs of the Society as well as the informal dinners at the City Club.

In the interests of the next committee, and in fact in the interests of all committees who have to arrange for dinners of one kind or another for the Society, the chairman of this committee wishes to urge upon your attention the importance of giving prompt notice by postal card of intention to attend the dinners. This is not intended in the slightest degree to include those who are unable to tell until the night of the meeting whether they can attend or not, or who have to change their minds at the last minute, but it is aimed at those who carelessly neglect to give notice when they fully intend to attend. The failure of a large number to state their intentions is a source of some anxiety and embarrassment to the committees, as the clubs or caterers who furnish dinners of this kind usually require an estimate of what the attendance will be, ahead of the meeting.

If your committee of 1916–1917 has succeeded in promoting better fellowship and acquaintance among the members of the Boston Society of Civil Engineers; has added attractiveness to the meetings; interested those not previously members, who at first attend as guests at the dinners and afterwards join the Society; has added in any degree to the success of the regular meetings, to that extent we have accomplished the purpose of our existence.

Very respectfully submitted,

HENRY A. SYMONDS,

Chairman Committee on Social Activities.

JANUARY 24, 1917.

TO THE BOARD OF GOVERNMENT OF THE BOSTON SOCIETY OF CIVIL ENGINEERS:

Gentlemen, — I have the honor to submit the following report on the JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS for the year 1916.

The usual ten numbers of the JOURNAL were issued, 1 250 copies of each

being printed. This number provides a few spare copies of each issue, but is not too large.

There were published, in 1916, 26 papers, 6 discussions and 9 memoirs of deceased members. Including the proceedings, papers, discussions, index and advertising, a total of 859 pages were printed. Eighty-six cuts and 21 inserted plates were used with the papers published, and the gross cost of the whole was $3 508.24. Receipts from subscriptions, sales of JOURNALS and advertisements made the net cost $1 883.81.

The increase in net cost over 1915 is due to the larger number of pages printed, to the use of more illustrations and to the very considerable increase in the cost of paper.

The details of the number of pages printed and the costs are given in the accompanying table.

Respectfully submitted,

(Signed) EDWARD C. SHERMAN, *Editor.*

APPLICATIONS FOR MEMBERSHIP.

[April 4, 1917.[

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

COOMBS, ANTHONY S., Allston, Mass. (Age 26, b. Chelsea, Mass.) Graduate of Mechanic Arts High School, 1908; continued education in post-graduate course (1909), I. C. S. course in civil engineering, course in reinforced concrete, Albany Evening High School, and special course in rein-

Month.	Pages of				No. of		Cost of							
	Papers.	Proc.	Index.	Adv.	Inserts.	Cuts.	Papers, Proc. and Index.	Cuts.	Adv'ts.	Reprints.	Postage, Wrapping and Mailing.	Editing.	Incidentals.	Copyright and Tax.
Jan.	42	14		17		7	$147.55	$16.20	$19.01	$10.50	$20.42		$3.55	
Feb.	33	12		17		2	130.35	3.80	19.50	4.08	16.96		.37	
Mar.	48	18		17		8	181.53	11.10	18.03	15.00	22.35		.85	
Apr.	54	36		17	6	10	328.43	22.05	22.16	25.50	20.01		1.24	
May	52	11		17	2	3	195.74	7.45	16.81	17.00	29.93		3.32	
June	100	14		16½		13	312.30	8.34	15.81	24.83	20.57		.40	
Sept.	108	18		16½	2	12	370.45	29.96	18.00	19.51	25.63		1.66	
Oct.	26	11		16½	1	7	147.00	22.35	20.25	15.36	20.33		1.00	
Nov.	21	13		16½		6	121.63	6.75	18.65	8.77	20.73		.76	
Dec.	24	14	10	16¼	10	18	283.26	116.16	24.70	12.50	25.63		3.26	
Total	508	161	10	167¼*	21	86	$2,218.24	$244.16	$192.92	$153.05	$222.56	$450.00	$16.41	$11.00

Total number of pages, 859.

Total gross cost		$3,508.34
Subscriptions	$64.40	
Sales of JOURNALS	86.13	
Advertisements	1 474.00	
		1 624.53
Total net cost		$1 883.81

* 18 pp. used each month; not set solid.

forced concrete at Harvard University, January to March, 1915; has passed New York State civil service examinations for tracer, chainman, rodman, leveler and assistant engineer; member of Technology Club of Syracuse during stay in that city. Timekeeper and stock clerk for Pittsburg-Eastern Co., from May, 1909, to January, 1910, and for Acme Engineering and Contracting Co. on New York Barge Canal work from January to April, 1910; from April, 1910, to August, 1911, with New York State Highway Dept. on plans, construction, etc.; from August, 1911, to January, 1915, with Alto Construction Co. of Utica, N. Y., on cost analysis work, etc.; from March to September, 1915, inspector with Carley Life Float Co., Cambridge, Mass.; from September, 1915, to date, field engineer and draftsman on building construction with Whidden-Beekman Co., Boston. Refers to L. J. Johnson and G. C. Whipple.

EATON, ARTHUR C., Worcester, Mass. (Age 33, b. Lunenburg, Mass.) Graduate of Civil Engineering Department, University of Vermont, 1907. In 1905, timekeeper for three months on Massachusetts highway construction; in 1906, rodman for three months on Catskill Aqueduct surveys; in 1907, rodman for five months with New York State Highway Dept.; during year 1907–08, instructor in civil engineering, University of Vermont; from 1908 to 1909, leveler with New York State Water Supply Comm.; for six weeks in 1909, with U. S. Geological Survey, Hydrographic Branch; from 1910 to 1911, leveler on New York State Barge Canal; from 1911 to 1912, assistant engineer with Barrows & Breed, Boston; from May, 1912, to date, assistant hydraulic engineer with Power Construction Co. of Worcester. Refers to H. K. Barrows, R. A. Hale, C. H. Pierce and A. T. Safford.

PHILLIPS, LAURENCE JOSLYN, Cambridge, Mass. (Age 20, b. Cambridge, Mass.) Student for two years at Rindge Manual Training School, Cambridge; is now completing second year of structural engineering course at Northeastern College, Boston Y. M. C. A. From August, 1911, to date, draftsman, timekeeper, etc., with Whidden-Beekman Co.; is now in charge of estimating department and of certain parts of construction work. Refers to C. S. Ell and Robert Rand.

LIST OF MEMBERS.

ADDITIONS.

BARRY, CHARLES G. . . . . Sandwich, Mass.
BRESTH, ALEXANDER . . . . 119 Pembroke St., Boston, Mass.
CROCKER, HAROLD S. . . . . City Hall, Brockton, Mass.
PIKE, WALDO F. . . . . 67 Dana St., Cambridge, Mass.

CHANGES OF ADDRESS.

ALBEE, EDWARD E. . . . . 11 Orris St., Melrose Highlands, Mass.
ALDEN, HOWARD K. . . . . 8 Ellsworth Ave., Cambridge, Mass.
AIKEN, ROY C. . . . . City Water Dept., Waltham, Mass.
APPLETON, ARTHUR B. . . . . 15 Dane St., Beverly, Mass.

BARNES, ROWLAND H. . . . . .88 Broad St., Boston, Mass.
BARKER, JOHN K. . . . . .33 Lyman St., Springfield, Mass.
BARRETT, ROBERT E. . . . . .308 Boylston St., Boston, Mass.
BATEMAN, LUTHER H. . . . . .Room 472, State House, Boston, Mass.
BRADBURY, ROYALL D. . .Clinton Wire Cloth Co., Sears Bldg., Boston, Mass.
BREEN, CHARLES H. . . . . .Beacon Chambers, Boston, Mass.
BRUNEL, RICHARD. . . . . .Moulton Engineering Corp., Portland, Me.
CARTER, CLARENCE E. . . . . .9 Masonic Block, Reading, Mass.
CLARK, CHARLES S. . . . . .Room 919, 141 Milk St., Boston, Mass.
COBURN, FRANK R., Valuation Dept., Grand Trunk Ry., Montreal, Canada
COBURN, WILLIAM H., care of Marshall & Co., Inc., 70 State St., Boston, Mass.
COFFIN, S. P. . . . . .Allston, Mass.
COGHLAN, JOHN H. . . . . .53 Wollaston Ave., Arlington, Mass.
DOLLIVER, HENRY F. . . . . .23 East Main St., Webster, Mass.
DURFEE, WALTER C. . . . . .8 Parley Vale, Jamaica Plain, Mass.
EBERHARD, WALTER C. . . . . 60 Church St., Rutland, Vt.
FARRELL, FRANCIS B. . . . . .158 Walnut St., Springfield, Mass.
FOOTE, FRANCIS C. . . . . .2541 Oliver Bldg., Pittsburgh, Pa.
HATHAWAY, ERWIN O.,
U. S. Office Public Roads, P. O. Bldg., Minneapolis, Minn.
HODGES, GILBERT. . . . . .Main Street Station, Franklin, N. H.
HOLMES, ALBERT J. . . . . .Hotel Belvedere, Bristol, R. I.
HOSMER, GEORGE L. . . . . .280 Washington St., Woburn, Mass.
HOXIE, ARTHUR E. . . . . .Laconia, N. H.
HOYT, LAWRENCE B. . . . . .15 Orient Place, Melrose, Mass.
HUGHES, HECTOR J. .M. I. T., 1–337, Cambridge, Mass.
HUNTER, WILLIAM B. .20 Rollins Place, Yonkers, N. Y.
HURLEY, HERBERT D., Commission on Waterways and Public Lands,
Dry Dock Office, South Boston, Mass.
JOHNSON, LEWIS J. . . . . .M. I. T., 1–280, Cambridge, Mass.
KENDALL, THEODORE R.,
Engrg. Editor, *American City*, 154 Nassau St., New York, N. Y.
KIMBALL, ERNEST R. . . . . .336 Mystic St., Arlington, Mass.
KITFIELD, EDWARD H. . . . . .85 Water St., Boston, Mass.
KLINK, NASSIME S. . . . . .25 Cowing St., West Roxbury, Mass.
LAWRENCE, WILLIAM H. . . . . .72 Sumner Rd., Dorchester, Mass.
McCORKINDALE, RALPH. . . . . .16 Summit Ave., Lawrence, Mass.
MULLEN, LUKE D. . . . . .Charlestown Trust Co., City Sq., Charlestown, Mass.
NASH, PHILIP C. . . . . .99 Winsor Ave., Watertown, Mass.
NICHOLS, CHARLES E. . . . . .147 Milk St., Boston, Mass.
O'BRIEN, JOSEPH H.,
Central Constr. Corp., Commonwealth Trust Co. Bldg., Harrisburg, Pa.
PITCHER, SAMUEL H. . . . . .Room 32, 44 Front St., Worcester, Mass.
RABLIN, JOHN R. . . . . .18 Tremont St., Boston, Mass.
RICHMOND, CARL G. . . . . .26 Hichborn St., Revere, Mass.
SARGENT, ALBERT F. . . . . .1 Salem St., Malden, Mass.

Seagrave, Arnold	27 Commercial Bldg., Woonsocket, R. I.
Skinner, Fenwick F.	Room 1705, 21 Park Row, New York, N. Y.
Smith, Sidney	91 Maple St., West Roxbury, Mass.
Smith, William H.	315 Mt. Vernon St., Dedham, Mass.
Snow, Leslie W.	8 Story St., Cambridge, Mass.
Sokoll, Jacob M.	20 Garden St., Boston, Mass.
Spear, Walter E.	Municipal Bldg., 22d Floor, New York, N. Y.
Terhune, Howard H.	care of Fred T. Ley Company, Springfield, Mass.
Wason, Leonard C.	1530 Beacon St., Brookline, Mass.
Webb, DeWitt C.	469 State House, Boston, Mass.
Williams, William F.	473 State House, Boston, Mass.
Winslow, Frederick I.	501 City Hall Annex, Boston, Mass.
Wood, Henry B.	413 State House, Boston, Mass.

DEATHS.

Semple, William J. C.	November 19, 1916.
Clapp, Otis F.	March 3, 1917.
Foster, Harry C.	March 5, 1917.
Wight, Willard W.	March 10, 1917.
Davis, Joseph P.	March 31, 1917.

RESIGNATIONS.

(In effect March 21, 1917.)

Ames, Bertram E.
Bickford, John W.
Bolling, George E.
Currier, George C.
Devine, Walter A.
Dowst, Everett F.
Dutton, Charles H.
Ferris, Raymond W.
Fox, Samuel M.
Gallene, Victor J.
Gladding, Raymond D.
Greene, Francis I.
Harrison, Christopher.
Higgins, Herman K.
Horton, Theodore.
Hosmer, Sidney.
Kirkpatrick, John J.
Langley, Miles E.
Newton, Jewett B.
Penard, Thomas E.
Phelan, John J.
Soper, George A.
Souther, Theodore W.
Stradling, David W.
Stucklen, Carl L.
Wales, Winthrop L.
Weston, Clarence M.

EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

399. Age 27. Has had good education in mathematics through trigonometry, and considerable experience in land-surveying with compass. Desires position with civil engineer which would give him opportunity to qualify as transitman.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Anticlines in Blackfeet Indian Reservation, Montana. Eugene Stebinger.

Coals in Area between Bon Air and Clifty, Tennessee. Charles Butts.

Earth, Sand-Clay and Gravel Roads. Charles H. Moorefield.

Farms, Forests, and Erosion. Samuel T. Dana.

Garrison and Philipsburg Phosphate Fields, Montana. J. T. Pardee.

Lumbering in Sugar and Yellow Pine Region of California. Swift Berry.

Nickel in 1915. Frank L. Hess.

Placer Deposits of Manhattan District, Nevada. Henry G. Ferguson.

Public Road Mileage and Revenues in Southern States, 1914.

Theory of Drying and Its Application to New Humidity-regulated and Recirculating Dry Kiln. Harry D. Tiemann.

Water-Supply Papers 392, 402, 419, 420 and 421.

State Reports.

Massachusetts. Annual Report of Homestead Commission for 1916.

Michigan. Report of Tuberculosis Survey of State Board of Health for 1915–16.

Municipal Reports.

Belmont, Mass. Annual Report of Water Commissioners for 1916.

Danvers, Mass. Annual Report of Water Commissioners for 1916.

Detroit, Mich. Annual Report of Water Commissioners for 1915–16.

Dover, N. H. Annual Report of Water Commissioners for 1916.

Reading, Mass. Annual Report of Water Commissioners for 1916.

Rutland, Vt. Annual Report for 1916.

Miscellaneous.

American Institute of Mining Engineers: Transactions for 1916, Vol. LIV.

American Society of Civil Engineers: Transactions, Vol. LXXX, 1916.

Comparison of Activated Sludge and Imhoff Tank-Trickling Filter Processes of Sewage Treatment. Harrison P. Eddy. Gift of author.

Canada, Department of Interior: Report of Hydrometric Surveys for 1915.

Treatise on Concrete Plain and Reinforced. Frederick W. Taylor and Sanford E. Thompson. 3d ed. Gift of S. E. Thompson.

Municipal Engineers of City of New York: Proceedings for 1915.

Practical Plan of Engineering Coöperation. F. H. Newell.

Reinforced Concrete Design Tables. M. Edgar Thomas and Charles E. Nichols. Gift of C. E. Nichols.

Sewage Treatment by Aëration and Activation. George T. Hammond. Gift of author.

Spray Engineering Co.: Condensed Summarization of Principal Spraco Developments, 1917.

Library Committee.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the 1st of each month.)

City of Boston. — PUBLIC WORKS DEPARTMENT. — HIGHWAY DIVISION, PAVING SERVICE.

Hill Top St.,	Granite Ave. to Hallet St.	Bituminous macadam.
Gaffney St.,	Commonwealth Ave. to B.& A.R.R.	Asphalt.
Caledonian Ave.,	Spring St. 200 feet northerly.	Grading.
Patten St.,	Hyde Park Ave. to Bourne St.	Bituminous macadam.
St. Rose St.,	South St. 416 feet westerly.	Bituminous macadam.
Amory St.,	Centre St. to Bragdon St.	Granite block.

PUBLIC WORKS DEPARTMENT.— BRIDGE AND FERRY DIVISION. — *Strandway Improvement.* — This work involves the extension of the concrete sewer outlets at H, Vale and Kemp streets and Crescent Ave.; the construction of a wooden bulkhead 1 700 ft. long, extending easterly from a point near Columbia Road Bridge into Old Harbor; reclamation of some seventy-five acres of flat land on the shores adjacent to Old Harbor by hydraulic fill; the construction of a fifty-six acre playground, surrounded by suitable drives and walks; and the construction of a new concrete bath-house near McKenzie Beach, capable of bathing four thousand people per day.

On this improvement there has been completed, to date, the construction of 400 ft. of 2 ft. by 3 ft. concrete sewer between H and I streets. The construction of the cofferdams for the Vale, Kemp streets and Crescent Ave. sewers is well under way; as is also the building of the bulkhead. Dredging and filling operations have been started.

Boston Elevated Railway Company, Bureau of Elevated and Subway Construction. — *Mystic River Bridge.* — The channel piers, abutments and intermediate piers, excepting two at the present or old channel, are completed. The steelwork for the bascule draw is substantially completed, and erection will probably begin on or about April 1; the balance of the steel

structure north of the draw is substantially completed, and erection is expected to begin some time during April.

Reconstruction of Malden Bridge. — Active work on the reconstruction of the bridge was begun in March, and the portions immediately adjacent to the new draw are now under construction. The fill north of the draw and on Alford St. as relocated will be started early in the coming month.

New York, New Haven and Hartford Railroad. — Construction Department. — Work consists of new 39-stall engine house, 95-ft. turntable, ash pits, boiler house, office building, water tank and necessary trackage.

During the past month completed following: Excavation for sand drying plant; driving concrete p les for ash pits and water tank and plugs; concrete foundations for engine house and turntable pit.

Progressing on the following: Pouring concrete foundation for office building, ash pits, and sand drying house; erecting brick and terra cotta, wood sash, louvres, timber framing, matched roof, timber rail supports and structural steel of engine house; excavation for water tank and plugs; relocating Western Union pole line; moving railroad company telephone and signal wires; laying temporary track to make fill for permanent tracks.

Vol. IV MAY, 1917 No. 5

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, MAY 16, 1917,

at 7.45 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Lieut. George D. Murray, United States Navy, will address the Society on "The Problems of Aviation as Applied to the Navy."

A representative of The Burgess Company, of Marblehead, will also be present and will speak on "Aviation," illustrating his remarks with lantern slides.

S. E. TINKHAM, *Secretary*.

PAPERS IN THIS NUMBER.

Address at the Annual Meeting, March 21, 1917. Richard A. Hale.

"China Mills Dam and Sluiceway of Suncook Mills." Arthur T. Safford.

"When to Dimension in Feet and Inches and When in Inches Alone." Sturgis H. Thorndike.

"Needs of the Engineers in War."

CURRENT DISCUSSIONS.

Paper.	Author.	Published.	Discussion Closes.
"History and Present Status of the Concrete Pile Industry."	Charles R. Gow.	April.	Aug. 10.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, April 11, 1917. — A special meeting of the Boston Society of Civil Engineers was held this evening in Lorimer Hall, Tremont Temple, Boston, and was called to order by the President, George C. Whipple, at 7.50 o'clock. There were about 250 members and guests, including representatives from the Boston Section of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the Boston Society of Architects and the Boston Architectural Club.

The President welcomed most cordially the members of other organizations which had been invited to join in this "Military Night" of the Society, and delivered a short address on what the Society should do in war time, and suggested certain work which the Society should take up. A communication was read by the Secretary in relation to the formation of a regiment of engineers and practical construction men in connection with the division of troops Colonel Roosevelt is planning to take to France if permission of the War Department is obtained, and enrollment blanks were presented.

The President then introduced the first speaker of the evening, Lieut.-Col. W. P. Chamberlain, Medical Corps, U. S. A., who spoke on "Military Sanitation," illustrating his remarks with lantern slides.

Capt. F. B. Downing, Corps of Engineers, U. S. A., followed with an interesting talk on the "Organization and Duties

of Engineer Troops," which was also illustrated with many slides, showing the work of the engineer, not only in our Civil War but in the present European War.

The last speaker was Capt. John F. Osborn, a member of the Society, who spoke particularly on the engineering instruction now being given in the First Corps of Cadets, Massachusetts National Guard, and on the movement to change the Corps from infantry to engineers. His talk was illustrated with lantern slides.

Mr. C. W. Sherman offered the following resolutions which were adopted by a unanimous vote:

Whereas, the First Corps of Cadets, Massachusetts National Guard, has, at the request of the War Department, undertaken to form a regiment of engineers to complete the organization of the New England division of the National Guard; and

Whereas, it is the sense of this meeting that the city of Boston is the only practicable location for the headquarters of such a regiment, because of the fact that it is the engineering center of New England, the location of the largest engineering societies in New England, and in close proximity to some of the leading engineering schools in the country; and

Whereas, it is the sense of this meeting that the Boston Society of Civil Engineers would be better able to coöperate with the First Corps of Cadets in the organization and maintenance of such a regiment than with any other existing military organization;

Now, therefore, be it resolved, that it is the sense of this meeting that the Boston Society of Civil Engineers should officially endorse the organization of such a regiment and coöperate in every way with the First Corps of Cadets in the organization and maintenance thereof; and be it further

Resolved, that the Board of Government be requested to appoint a committee which shall immediately take steps for the coöperation on the part of this Society in every possible way in the organization of such a regiment.

Past President Gow offered the following, which was adopted by a unanimous vote:

Voted: That the President of the Society be authorized to appoint a committee to study the necessary steps for the closer coöperation of the sanitary engineers with the medical division of our army.

After passing a vote of thanks to Colonel Chamberlain and Captain Downing, for their kindness in coming before the Society and giving the interesting and instructive addresses to which we had listened, the Society adjourned.

S. E. Tinkham, *Secretary*.

Boston, April 18, 1917. — A regular meeting of the Society was held this evening at Chipman Hall, Tremont Temple, and was called to order by the President, George C. Whipple, at 8 o'clock. There were 90 members and visitors present.

The reading of the record of the annual meeting was dispensed with, and it was approved as printed in the April Journal.

The Secretary announced the election, by the Board of Government, of the following members: Stuart E. Coburn, Grover Cleveland Coffin and Frank Sidney Hanf.

The Secretary reported, for the Board of Government, that, under authority of a vote passed at the annual meeting, the following committees had been appointed:

On the Library — S. E. Tinkham, H. F. Bryant and F. I. Winslow.

On Publication — C. W. Sherman, L. E. Moore and A. W. Dean.

On Papers and Program — G. C. Whipple, S. E. Thompson, C. T. Fernald, A. W. French, H. J. Hughes, E. H. Rockwell and S. E. Tinkham.

On Membership — R. A. Hale, E. R. Kimball and P. C. Nash.

On Run-Off — A. T. Safford, H. S. Boardman, X. H. Goodnough, R. A. Hale, H. A. Moody, C. H. Pierce, G. E. Russell, C. W. Sherman, W. F. Uhl and D. M. Wood.

On Revision of Civil Service Rules — F. H. Fay, C. R. Gow, R. M. Whittet, J. E. Carty and E. H. Rogers.

The President announced the death of Past President Joseph P. Davis, which occurred on March 31, 1917, and later in the meeting Vice-President Sherman announced the death of Otis F. Clapp, a member of the Society, which occurred on March 3, 1917.

The President was requested, by vote, to appoint committees to prepare memoirs. He has appointed the following committees:

On memoir of Joseph P. Davis, Messrs. F. P. Stearns and E. W. Howe.

On memoir of Otis F. Clapp, Messrs. W. D. Bullock and I. S. Wood.

The President then introduced Past President Charles R. Gow, who, with the aid of numerous lantern slides, gave a most interesting description of the various forms of concrete piles, substantially as covered by his paper printed in the April, 1917, number of the JOURNAL of the Society.

With Vice-President Charles W. Sherman in the chair, a discussion followed in which the following took part: Mr. Thomas W. Clarke, of the New England Foundation Company; Mr. L. Hart, of the Raymond Concrete Pile Company; Mr. John T. Scully and Mr. H. E. Sawtell.

Adjourned.

S. E. TINKHAM, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[May 4, 1917.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Long, William James, Woonsocket, R. I. (Age 24, b. Woonsocket, R. I.) Educated in public schools of Woonsocket and at Rhode Island School of Design, Providence; is now taking course in reinforced concrete engineering. Spent three summers as time clerk and waterboy for Woonsocket Water Dept.; for past six years has been with Eastern Construction Co., engineers and general contractors, Woonsocket; has served as time clerk, cost clerk, subforeman, foreman, and draftsman, and is now estimator for that company. Refers to F. A. Caldwell, D. R. Howard, F. H. Mills, C. F. Parker and Arnold Seagrave.

Palmer, Walter Thomas, Faneuil, Mass. (Age 27, b. Caywood, Ohio.) From 1910 to 1911, student at Ohio State University; in 1911 and from 1915 to date, evening student, Carnegie Inst. of Technology. From 1907 to 1910, rodman with Rock Island Ry.; from 1911 to 1913, resident engineer with Lake Erie & Northern Ry.; from 1913 to 1915, engineer on erection of structural steel and reinforced concrete with Dominion Bridge Co. and Cramp & Co. respectively; from 1915 to 1917, with Witherow Steel Co. on design of reinforced concrete and sale of reinforcing steel; is now New England manager for this company. Refers to W. M. Bailey and B. S. Brown.

Probst, Arthur Frederick, Roslindale, Mass. (Age 38, b. Brooklyn, N. Y.) From February, 1896, to March, 1900, with Keuffel & Esser Co., New York, N. Y.; from March, 1900, to September, 1902, with Eugene Dietzgen Co., New York; employed temporarily by John Matthews, Inc., manufacturers of carbonated waters; from February, 1904, to August, 1906, with Kolesch & Co., manufacturers of surveying instruments and importers of drawing materials; September 1, 1906, became associated with G. G. Ledder under firm name of Ledder & Probst; since December 1, 1909, has conducted the business alone, and is now president and treasurer of Ledder & Probst, Inc. Refers to H. S. Adams, H. F. Bryant, J. H. Duffy, R. K. Hale, B. L. Makepeace, E. E. Pettee, R. H. Whiting, F. J. Wood and H. B. Wood.

St. Amand, Louis J., Roxbury, Mass. (Age 27, b. Boston, Mass.) Graduate of Boston English High School, 1909; later took courses in structural designing, reinforced concrete and hydraulics at Franklin Union. In 1910 and 1911, transitman with Fuller Whitney Surveys Corp'n; in 1911–12, assistant engineer with Silverman Engrg. Co., and with T. A. Appleton; in 1912, assistant in office of Whitman & Howard; in 1913 and 1914, construction engineer for Tyson, Weare & Marshall on construction of New Fish Pier; in 1914–15, construction engineer with J. J. Prindiville Co., on new state armory; in 1916, engineer with W. F. Kearns Co.; is now engineer with James E. McLaughlin, architect. Refers to E. W. Colby, Channing Howard, D. P. Kelley, T. R. Lyons and E. B. Richardson.

Ullian, Hyman Benjamin, Dorchester, Mass. (Age 21, b. Lowell, Mass.) Graduate of Mass. Inst. of Technology, 1916, degree of B.S. From June to November, 1912, resident engineer with Massachusetts Highway

Comm.; from December, 1916, to March, 1917, with Fay, Spofford, and Thorndike; is now opening office in land development and subdivision work in Detroit, Mich. Refers to C. R. Berry, R. W. Horne, T. F. McSweeney, H. F. Sawtelle and C. M. Spofford.

LIST OF MEMBERS.

ADDITIONS.

Mattson, William R. 2 Vogel Terrace, Brookline, Mass.
Sheils, Henry C. . . . . 1079 Columbus Ave., Boston, Mass.

CHANGES IN ADDRESS.

Atwood, Thomas C. . The Foundation Co., 233 Broadway, New York, N. Y.
Brown, C. Leonard . . . . 29 South St., Southbridge, Mass.
Chapman, Benjamin R. . . . . The Checkerton, Brockton, Mass.
Eberhard, Walter C. 12 Spellman Terrace, Rutland, Vt.
Elkins, Clayton R. . . Room 305, Central Union Depot Bldg., Cincinnati, O.
Ferguson, John N.,
Commission on Water Ways and Public Lands, State House, Boston, Mass.
Foote, Francis C. . . . . 1200 Jones Bldg., Pittsburgh, Pa.
Fritz, Charles A. . . . . 27 School St., Manchester, Mass.
Green, Howard W., Miraflores Water Purification Plant, Corozal, C. Z.
Hyde, Edward R. . . . . Manila, P. I.
Jeffers, Robert B.,
Beechwood Park, care of 734 Ridgeway Ave., Rochester, N. Y.
Kimball, Joseph H. . . . . Miami Conservancy District, Dayton, Ohio
Knowles, Morris,
1200 B. F. Jones Law Bldg., cor. Fourth Ave. and Ross St., Pittsburgh, Pa.
Newsom, Reeves J. . . . . 33 Intervale St., East Lynn, Mass.
Runels, Ralph E. . . . . Lowell, Mass.
Smith, George A. . . . . Town Engineer, Norwood, Mass.
Sokoll, Jacob M. . . . . P. O. Box 453, Greenfield, Mass.
Stratton, George E. . . . . U. S. Reclamation Service, Malta, Mont.

DEATH.

Glover, Albert S. . . . . April 23, 1917

RESIGNATIONS.

(In effect March 21, 1917.)

Ackerman, Alexander S.
Allardice, James P.
Bainbridge, Randolph
Collins, Harry B.
Ledder, Gottfred G.
Pinkham, Millard B.
Simmons, John E.

EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

400. Age 26. Graduate of Dartmouth College, degree of B.S. Has had three years' experience as transitman and assistant engineer on municipal work; experience includes drafting and other office work, paving and sewer construction. Will consider any position along civil engineering lines. Salary desired, $25 per week.

401. Age 24. Educated in public schools and at Technical College, Nova Scotia. Was for two years provincial land surveyor in that province; has also had some experience in general engineering and construction work. Desires position as transitman. Salary desired, $60 per month.

LIBRARY NOTES.

Recent Additions to the Library.

On Military Engineering and Related Subjects.

Notes on Military Explosives. Erasmus M. Weaver.

Elements of Military Hygiene. P. M. Ashburn.

Fundamentals of Military Service. Lincoln C. Andrews and Leonard Wood.

Manual of Military Hygiene. Valery Havard.

Military Map Reading. C. O. Sherrill.

Military Preparedness and the Engineer. Ernest F. Robinson.

Military Sketching and Map Reading. Loren C. Grieves.

Mosquito Control in Panama. Joseph A. LePrince and A. J. Orenstein.

Notes on Field Fortification. Army Field Engineer School.

Studies in Minor Tactics. Department of Military Art, Army Service Schools.

U. S. Government Reports.

Report of National Coast Defense Board, 1906.

Production of Lumber, Lath and Shingles in 1915 and Lumber in 1914. J. C. Nellis.

Sewage Disposal on the Farm. George M. Warren.

The Windbreak as a Farm Asset. Carlos G. Bates.

State Reports.

Connecticut. Biennial Report of Highway Commissioner for Term ending September 30, 1916.

Illinois. Addresses and Papers on Insurance. Rufus M. Potts.

New Hampshire. Annual and Statistical Report of Public Service Commission for 1914–15; Reports and Orders of Public Service Commission for two years ending August 31, 1916.

County Reports.

Essex County, Mass. Engineer's Report for 1916.

Municipal Reports.

Auburn, N. Y. Annual Report of Water Board for 1916.

Boston, Mass. Annual Report of Public Works Department for 1915.

Brookline, Mass. Annual Report of Water Board for 1916.

Burlington, Vt. Annual Report of Water Department for 1916.

Concord, Mass. Annual Report of Board of Health for 1916.

Concord, Mass. Annual Report of Road Commissioners for 1916.

Laconia, N. H. Annual Reports of Board of Public Works for 1916.

New Bedford, Mass. Annual Report of Engineering Department for 1916.

New Bedford, Mass. Annual Report of Water Board for 1916.

New York, N. Y. Report to Board of Estimate and Apportionment on Design of Outlet Sewers and Sewer Outlets, 1917.

Northampton, Mass. Annual Report of Water Commissioners for 1916.

Plymouth, Mass. Annual Report of Water Commissioners for 1916.

Springfield, Mass. Annual Report of Water Commissioners for 1916; Office Reference Pamphlet, Municipal Water Works, 1916.

Wellesley, Mass. Annual Reports of Water and Municipal Light Commissioners for 1916.

Miscellaneous.

Bibliography of Colloids. Thorndike Saville. Gift of author.

Canada, Department of Mines: Feldspar in Canada, by Hugh S. de Schmid; Cobalt Alloys with Non-Corrosive Properties, by Herbert T. Kalmus and K. B. Blake.

Report on Destructive Action of Sea Water on Concrete. W. Watters Pagon. Gift of author.

State Sanitation: A Review of the Work of the Massachusetts State Board of Health. George Chandler Whipple. Gift of Harvard University Press.

University of Maine: Tests on Corrugated Metal Culverts.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

Commonwealth of Massachusetts.—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.* — A contract has been awarded to F. A. Mazzur & Company for furnishing and erect-

ing, at the Arlington Pumping Station, a steam turbine-driven centrifugal pumping unit, having a capacity of 3 000 000 gals. in twenty-four hours when pumping against a head of 320 ft.

Surveys have been completed for a 66 000-volt transmission line between the Wachusett and the Sudbury dams, approximately fifteen miles in length.

Metropolitan Water and Sewerage Board. — *Sewerage Works.* — Work in progress: Section 98 and Section 102, Wellesley Extension.

Work contemplated: Sections 99, 100 and 101, Wellesley Extension; extension, Deer Island outfall.

Metropolitan Park Commission. — *Charles River Reservation.* — The work of completing the construction of reinforced concrete bridge over the Charles River at North Beacon Street, Boston and Watertown, is in progress.

Work of completing the construction of reinforced concrete bridge over the Charles River at Commonwealth Avenue, Newton and Weston, is in progress.

General. — Work of road repairs in the various divisions is in progress.

Boston Transit Commission. — *Dorchester Tunnel.* — The work on Section F, which includes the Broadway Station and the approach for surface cars leading from Foundry Street to the upper level of the station, is in progress.

Work on Section G, which extends from West Fourth Street to Old Colony Avenue, and includes the crossing under the New York, New Haven & Hartford Railroad tracks near West Sixth Street, is in progress.

Work on Section J, which includes the station at Andrew Square, is in progress.

On account of the scarcity of skilled labor, etc., the contractors have not been able to complete their work at the times stipulated in the contracts. After these contracts have been completed, there will remain to be let the contracts for the interior finish of these stations.

The repaving of Summer Street over the portion of the

tunnel extending from High Street, through Dewey Square and to Dorchester Avenue, has been awarded to Henry S. Clark, and work will begin at once.

City of Boston. — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Work is in progress on the following streets:

West Broadway,	from Dorchester Ave. to E St.	Asphalt.
St. Rose St.,	from South St., about 416 ft. northerly.	Bituminous macadam.
Granada Ave.,	from Metropolitan Ave. to Ethel St .	Bituminous macadam.
Cornell St.,	from Orange St. to Colberg Ave.	Bituminous macadam.
Caledonian Ave.,	from Spring St., 200 ft. northerly.	Grading.
Augustus Ave.,	from Metropolitan Ave. to Ethel St.	Bituminous macadam.
Vista St.,	from Augustus Ave. to Malvern St.	Bituminous macadam.
Patten St.,	from Hyde Park Ave. to Bourne St.	Bituminous macadam.
Lorne St.,	from Harvard St., 650 ft. northerly.	Asphalt.
Temple St.,	from Spring St. to Ivory St.	Asphalt.
Epping St.,	from Washington St. to Norfolk St.	Asphalt.
Lithgow St.	from Talbot Ave. to Wainwright St.	Asphalt.
Hill Top St.,	from Granite Ave. to Hallet St.	Bituminous macadam.
Amory St.,	from Centre St. to Bragdon St.	Granite block.
Norfolk Ave.,	from Shirley St. to Burrell St.	Artificial walks.
Albany St.,	from Dover St. to Northampton St.	Granite block.
Canal St.	from Haymarket Sq. to Causeway St.	Granite block.
Lincoln St.,	from Essex St. to Beach St.	Granite block.
McKinley Sq.,	from State St. to Central St.	Granite block.
Asphalt patching,	Miscellaneous streets.	Asphalt.

New York, New Haven and Hartford Railroad. — CONSTRUCTION DEPARTMENT. — Work consists of new 39-stall engine house, 95 ft. turntable, ash pits, boiler house, office building, water tank and necessary trackage.

During past month completed the following: Foundations for office building; placing timber work on turntable rim, and erecting superstructure of sand drying plant.

Progressing on the following:

Engine house: Erection of superstructure and installation of heating and drainage systems.

Office building: Erection of superstructure and installation of plumbing system.

Boiler house: Pouring concrete foundations.

Building ash pits.

Excavating for and pouring concrete foundations for water tank and plugs.

The Fore River Shipbuilding Co., Quincy, Mass., has the following work in progress:

Two oil tank steamers for Texas Co.

Two oil tank steamers for Mexican Petroleum Co.

Five cargo steamers for E. F. Luckenbach.

Two cargo steamers for Cunard S. S. Co.

It is not considered expedient to publish the list of government work on hand at this time.

Vol. IV JUNE, 1917 No. 6

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, JUNE 13, 1917,

at Norumbega Park, Newton, in connection with the joint Field Day of the New England Water Works Association and this Society. This meeting will consist of a brief business meeting, which will be held at the conclusion of the dinner.

Business of the meeting: Announcement of the result of the letter ballot on the adoption of the Resolution on the Formation of a Regiment of Engineers.

Action on the following vote, which was passed at the last meeting of the Society: *Voted,* that a sum not exceeding five hundred dollars be appropriated from the income of the Permanent Fund for the improvement and furnishing of the Society rooms.

Under the By-Laws, it requires an affirmative vote of two thirds at two successive regular meetings, to make an appropriation from the Permanent Fund.

S. E. TINKHAM, *Secretary.*

PAPERS IN THIS NUMBER.

"The Engineering Society in War Time." George C. Whipple.

"Military Sanitation." W. P. Chamberlin.

"Organization and Duties of Engineer Troops." Frederick B. Downing.

"Engineering Instruction Now being Given by the First Corps Cadets and the Formation of a New Engineer Regiment." John F. Osborn.

Current Discussions.

Paper.	Author.	Published.	Discussion Closes.
"History and Present Status of the Concrete Pile Industry."	C. R. Gow.	April.	Aug. 10.
"China Mills Dam and Sluiceway of Suncook Mills."	A. T. Safford.	May.	Aug. 10.
"When to Dimension in Feet and Inches and When in Inches Alone."	S. H. Thorndike.	May.	Aug. 10.

MINUTES OF MEETING.

Boston, May 16, 1917. — A regular meeting of the Society was held this evening in Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, George C. Whipple. There were 92 members and visitors present.

The reading of the record of the regular meeting of April 18, and that of the special meeting of April 11, was, by vote, dispensed with and they were approved as printed in the May Journal.

The President reported for the Board of Government that it had elected to membership in the grade of member, Messrs. Arthur C. Eaton and Joseph León O'Neil. The President announced the death of Albert S. Glover, a member of the Society, which occurred on April 23, 1917, and by vote he was authorized to appoint a committee to prepare a memoir. The President has named, as that committee, Messrs. Richard A. Hale and Charles W. Sherman.

On recommendation of the Board of Government, it was voted to hold the next regular meeting on June 13, 1917.

The Board of Government recommended the adoption of the following resolution:

Whereas, engineers and engineer troops are of prime importance in modern warfare, and

Whereas, the organization of engineer troops is particularly a subject for coöperation on the part of societies of engineers, and

Whereas, a regiment of engineers is now being organized in the Massachusetts National Guard, by the transformation and enlargement of the First Corps of Cadets; therefore

Be It Resolved, that the Boston Society of Civil Engineers endorses the formation of such regiment of engineers, and pledges to it its support and assistance.

On motion of Mr. Sherman, the resolution was adopted by a unanimous vote. The President stated that, in accordance with the requirement of the constitution, the resolution would be submitted to the full membership by letter ballot.

By vote, the Board of Government was authorized to canvass the letter ballot and report to the Society at the next meeting.

The President submitted, for the Board of Government, its recommendation that a sum not exceeding five hundred dollars be appropriated from the income of the Permanent Fund for the improvement and furnishing of the Society rooms. On motion of Mr. Marston, the following vote was adopted unanimously, 36 voting in its favor:

Voted: That a sum not exceeding five hundred dollars be appropriated from the income of the Permanent Fund for the improvement and furnishing of the Society rooms.

The President then introduced the first speaker of the evening, Lieut. George D. Murray, United States Navy, who addressed the Society on "The Problems of Aviation as Applied to the Navy."

Mr. Greely S. Curtis described in a most interesting manner, with the aid of lantern slides, various forms of air planes, particularly those made by the Burgess Company, of Marblehead.

Prof. Edwin B. Wilson, of the Massachusetts Institute of Technology, spoke briefly of the theory of the aeroplane, and

Mr. Clifford L. Webster, aviator for the Burgess Company, gave some interesting experiences in aërial navigation and method of instructing pupils.

A general discussion followed, in which the speakers of the evening freely answered many questions propounded to them.

On motion of Mr. Gow, the thanks of the Society were voted to Lieutenant Murray, Professor Wilson and Mr. Webster, for the interesting addresses and discussions which they had contributed.

Adjourned.

S. E. TINKHAM, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[June 4, 1917.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

GOULD, GARDNER SABIN, Needham, Mass. (Age 31, b. Newton Upper Falls, Mass.) Graduate of Mass. Inst. of Technology, 1907, civil engineering course. From 1907 to 1910, with W. S. Johnson; from 1910 to 1911, with W. H. McElwain Co.; during 1912, with Boston Cons. Gas Co., construction department; from 1913 to 1915, with F. A. Barbour on water-works design and construction; during 1916, with Moulton Engrg. Corp'n, Portland, Me.,

on wharf and heavy mill construction; is now superintendent for Roy H. Beattie, Inc., on harbor and wharf construction. Elected a member of Sanitary Section October 7, 1908, and now desires to be transferred to full membership in the Society. Refers to F. S. Bailey, F. A. Barbour, H. N. Cheney, J. A. Gould, W. S. Johnson and D. S. Reynolds.

TERHUNE, EDWARD ANDRUS, Jr., Dorchester, Mass. (Age 22, b. Dorchester, Mass.) Senior at Tufts College Engrg. School, structural department. Refers to E. H. Rockwell, F. B. Sanborn, R. C. Smith and H. H. Terhune.

LIST OF MEMBERS.

ADDITIONS.

DELANO, RAY O. . . . . North Duxbury, Mass.

DEATH.

LOCKE, FRANKLIN B. . . . . May 11, 1917.

LIBRARY NOTES.

BOOK REVIEWS.

STATE SANITATION, Volume I, by George Chandler Whipple; published by Harvard University Press, Cambridge, Mass. Cloth, 6 in. by 9 in., ix+377 pages, 20 illustrations. $2.50.

*Reviewed by Harrison P. Eddy.**

A review for the JOURNAL of the Boston Society of Civil Engineers, of a book written by the Society's President, devoted to the past work of the Massachusetts State Board of Health, so largely executed by members of the Society, appears to be very much of a family affair. To those who have been looking forward to the publication of Professor Whipple's latest book, it will be distinctly pleasing to have the first volume, which contains, in Part I, a review of the work of the Massachusetts State Board of Health and, in Part II, the classic report, somewhat abridged, of the Massachusetts Sanitary Commission of 1850. In presenting the subject of state sanitation the writer has very appropriately utilized the history of sanitation in Massachu-

* Of Metcalf & Eddy, 14 Beacon Street, Boston, Mass.

setts as the basis of his discussion. To many readers, history is dry and tiresome, but the author has so presented it in this volume that it is inspiring as well as entertaining.

The description of the early history of public health in Massachusetts, as presented in the first chapter, is replete with interesting facts, such as the introduction in 1800 of the process of vaccination for smallpox, by Dr. Benjamin Waterhouse; the discovery, by Dr. W. T. G. Morton, in 1846, that sulphuric ether would produce anesthesia, and the formation of the Boston Aqueduct Company in 1795, to bring water into the city from Jamaica Pond, a distance of 4.85 miles, to a reservoir at Fort Hill. Later, the report of the Massachusetts Sanitary Commission of 1850 is brought to the attention of the reader, and a brief account is given of the work of Lemuel Shattuck, to whom the author gives much credit for originating the movement resulting in the appointment of the commission, and also for a major part in the preparation of the notable report which to-day rings true in almost every detail after fifty-six years of the most remarkable discovery and progress in sanitary science the world has ever seen.

The organized work of the state in the field of public health is divided into the following four epochs:

Beginnings of the State Board of Health, 1869–1879.

The Board of Health, Lunacy and Charity, 1879–1886.

The State Board of Health Reorganized, 1886–1914.

The State Department of Health, 1914–1916.

In discussing the methods of the board, the author states:

"Its organization and work have been non-partisan; its functions have been conceived to be advisory rather than coercive, educational rather than punitive, yet, when occasion required, it has not hesitated to demand the exercise of the police power of the state through its legal machinery."

The third epoch will prove familiar reading to many recipients of the JOURNAL, for within it have been conceived and executed the Lawrence Experiment Station and its work, the Metropolitan Sewerage Works, the Lawrence water filter, the Metropolitan Water Works and the Charles River Basin — all works in which the members of the Boston Society of Civil

Engineers take just pride. They are the accomplishments of some of its most honored members. While these great enterprises, with the exception of the Experiment Station, were the work of other public boards, they were passed upon in one way or another by the state board of health.

In the fifth chapter the author discusses in an interesting manner the " Health of the People," and points out the " rather peculiar fact that the only way in which we measure the health of a people is by taking account of the amount of sickness, or the number of deaths which occur," and he states further that " the time is coming when we shall measure health not in terms of doctor's bills, but in stature and strength, and the ability to work and to enjoy life; while the healthfulness of a place will be measured not only in terms of death-rates but by the capability of the environment to promote good living."

The chapter upon " Protection of the Purity of Inland Waters," starting with the Act of 1886, giving the state board of health general oversight and care of all inland waters, deals with the several and various activities of the board under this authority; while the chapter upon the " Lawrence Experiment Station " gives to the board credit for the experimental work which has been accomplished at this station.

Passing rapidly over " Later Engineering Work " and the " Cost and Achievements of the State Board of Health," one comes to what is perhaps the most interesting chapter in the volume, — " Personalia," — where will be found a most fascinating discussion of the part taken in the work of the Board, by many of its illustrious members and employees. Due credit is given to Dr. Henry P. Walcott, chairman 1886–1914, during which time the board " spent over two million dollars of the state's money for purposes of public health through the appropriations for the state board of health, and made recommendations which resulted in the expenditure of sixty million dollars for the Metropolitan water supply, Metropolitan sewerage works and other public improvements." That such sums were forthcoming throughout a period of about twenty-nine years is a sufficient testimonial of the public confidence in the personnel of the board and its policies. Among the past and present mem-

bers of the Boston Society of Civil Engineers thirty-six are mentioned as having been connected with the work of the board, including Hiram F. Mills and Frederic P. Stearns, both honorary members of the Society.

The report of the Massachusetts Sanitary Commission, comprising the second part of the volume, was dated April 25, 1850, and sets forth a "Plan for a Sanitary Survey of the State," with remarkable clearness and insight into the requirements for and scope of the work of a state board of health even in modern times. The author makes the following interesting comment upon this report:

"In reading the report, one omission will be found conspicuous; there was no reference to bacteriological science; for this was long before the days of Pasteur. All the more remarkable, therefore, were the plans presented. Without a knowledge of the germ theory, Shattuck had an abiding faith in preventive medicine. Perhaps, after scientists have pushed bacteriological methods to their natural or economical limit, they will turn back to the simple and fundamental principles of sanitation so well set forth in this classic report."

Reinforced Concrete Design Tables: A Handbook for Engineers and Architects, by M. Edgar Thomas and Charles E. Nichols. New York: McGraw-Hill Book Co. Flexible leather, 4 in. by 7 in., 208 pages. $3.00.

*Reviewed by George H. Stearns.**

This handbook is intended, as the authors state, to serve the same purpose for the designer in reinforced concrete that the handbooks of the various steel companies do for the designer in steel.

The book includes about 200 pages of tables and explanations, covering a wide range of specifications.

The notation is that of the Special Committee.

The tables include slabs, simple and T beams, beams with compression steel; also square, round and hooped columns and longitudinal and hooping steel.

The book is of handy size and shape; the tables are clear and well arranged, and have been found by trial to well serve the purpose for which they were intended.

* Assistant Engineer, Boston Transit Commission, 15 Beacon Street, Boston.

Recent Additions to the Library.

On Military Engineering and Related Subjects.

Engineer Field Manual. Corps of Engineers, U. S. Army.

Military Topography for Mobile Forces. Capt. C. O. Sherrill.

Sanitation in War. Maj. P. S. LeLean.

U. S. Government Reports.

Baked Shale and Slag Formed by Burning of Coal Beds. G. Sherburne Rogers.

Mortality Statistics for 1915.

Newington Moraine: Maine, New Hampshire, and Massachusetts. Frank J. Katz and Arthur Keith.

Public Road Mileage and Revenues in Central, Mountain, and Pacific States, 1914.

Triangulation and Primary Traverse, 1913–1915. R. B. Marshall.

Useful Minerals of United States. Frank C. Schrader, Ralph W. Stone and Samuel Sanford.

Water-Supply Papers 396, 407, 416 and 417.

State Reports.

Connecticut. Annual Report of Public Utilities Commission for 1915–16.

Maine. Annual Report of Public Utilities Commission for 1916.

Massachusetts. Annual Report of Gas and Electric Light Commissioners for 1916.

Massachusetts. Annual Report of State Department of Health for 1915.

Municipal Reports.

Cambridge, Mass. Annual Report of Water Board for 1915–16.

Fall River, Mass. Annual Report of City Engineer for 1916.

Holyoke, Mass. Annual Report of Water Commissioners for 1916.

Milwaukee, Wis. Annual Report of Sewerage Commission for 1916.

Newton, Mass. Annual Report of Water Commissioner for 1916.

North Adams, Mass. Annual Report of City Officers for 1916.

Woburn, Mass. Annual Report of Department of Public Works for 1916.

Woonsocket, R. I. Annual Report of Water Commissioners for 1916.

Miscellaneous.

Bausch & Lomb Optical Co.: Range Finders for Army and Navy.

Elements of Euclid, with coloured diagrams and symbols. Oliver Byrne. Gift of Thos. W. Clarke.

Hydrated Lime Bureau: Modern Methods in Concrete Construction.

Public Utility Rates. Harry Barker.

Valuation, Depreciation and the Rate-Base. Carl Ewald Grunsky.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

Commonwealth of Massachusetts.—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.* — On May 11, 1917, bids were received for a horizontal fire tube boiler for the Arlington Pumping Station, to be used in connection with a new centrifugal pumping unit, and the contract was awarded to the lowest bidder, the New England Iron Works Company, for $2,296.

METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.* — Work in progress: Section 98 and Section 102, Wellesley Extension.

Work contemplated: Sections 99, 100 and 101, Wellesley Extension; extension, Deer Island outfall.

Metropolitan Park Commission. — The following work is in progress:

Charles River Reservation. — The work of completing the construction of reinforced concrete bridge over the Charles River at North Beacon Street, Boston and Watertown, is in progress.

The work of completing the construction of reinforced concrete bridge over the Charles River at Commonwealth Avenue, Newton and Weston, is in progress.

General. — Work of road repairs in the various divisions is in progress.

Boston Transit Commission. — *Dorchester Tunnel.* — The work on Section F, which includes the Broadway Station and the approach for surface cars leading from Foundry St. to the upper level of the station, is in progress; also the widening of Broadway and a portion of the Broadway bridge to make room for an enclosed surface transfer area.

Work on Section G is in progress at and near the bridge over the New York, New Haven & Hartford Railroad tracks near West Sixth St.

Work on Section J, at Andrew Sq., for the Andrew Station, is in progress.

Summer St., over a portion of the tunnel extending from High St. to the bridge over Fort Point Channel, is being repaved with new granite blocks with cement grout joints.

City of Boston. — Public Works Department, Highway Division, Paving Service. — Work is in progress on the following streets:

Gaffney St.,	Commonwealth Ave. to B. & A. R. R.	Asphalt.
Fordham Rd.,	Commonwealth Ave. to Brighton Ave.	Asphalt.
St. Rose St.,	South Street to 415 ft. northerly.	Bituminous macadam.
Granada Ave.,	Metropolitan Ave. to Ethel St.	Bituminous macadam.
Cornell St.,	Orange St. to Colberg Ave.	Bituminous macadam.
Caledonian Ave.,	Spring St. to 200 ft. northerly.	Grading.
Patten St.,	Hyde Park Ave. to Bourne St.	Bituminous macadam.
Lorne St.,	Harvard St. 650 ft. northerly.	Asphalt.

Epping St.,	Washington St. to Norfolk St.	Asphalt.
Lithgow St.,	Talbot Ave. to Wainwright St.	Asphalt.
Hill Top St.,	Granite Ave. to Hallet St.	Bituminous macadam.
Caspian Way,	Savin Hill Ave. to 520 ft. easterly.	Bituminous macadam.
Harwood St.,	Willowwood St. to Lucerne St.	Asphalt.
Upland Ave.,	Park St. to Melville Ave.	Asphalt.
Amory St.,	Centre St. to Bragdon St.	Granite block.
Homestead St.,	Humboldt Ave. to Elm Hill Ave.	Asphalt.
Albany St.,	Dover St. to Northampton St.	Granite block.
Canal St.,	Haymarket Sq. to Causeway St.	Granite block.
McKinley Sq.,	State St. to Central St.	Granite block.
Beach St.,	Harrison Ave. to Atlantic Ave.	Granite block.
Haymarket Sq.,		Granite block.
Tyler St.,	Oak St. to Curve St.	Asphalt.
West Broadway,	Dorchester Ave. to E St.	Asphalt.

New York, New Haven & Hartford Railroad. — Construction Department. — Progressing on erection of engine facilities at Southampton St., Boston, Mass. Work consists of new 39-stall engine house, 95-ft. turntable, ash pits, boiler house, office building, water tank and necessary trackage.

Aberthaw Construction Company. — Has following work of interest:

New shipways for the Fore River Shipbuilding Corp., at Quincy, for the 50 000-ton battle cruiser. This is a shipways complete, including foundations, grading, and superstructure of steel and four heavy cranes, three with a lifting power of 7½ tons, one with 50 tons. These cranes have a span of 130 ft. approximately. This is a rush job for the Government, and is to be finished in September.

A factory 150 ft. x 400 ft., for the Colt's Patent Fire Arms Mfg. Co., Hartford, Conn., for the manufacture of revolvers. This is an unusually fast job. From contract to completion, ready for the installation of equipment, there is but little over three months.

We are also building at Donora, Pa., one hundred monolithic concrete residences for workingmen for the American Steel and Wire Co. This is a new departure in the construction of workingmen's homes, and should be of interest to the engineering profession.

Vol. IV SEPTEMBER, 1917 No. 7

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, SEPTEMBER 19, 1917,

at 7.45 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Frank A. Barbour, supervising engineer at Camp Devens, Ayer, Mass., will give an informal general description of the work at that camp, illustrating his talk with lantern slides. As many of the chiefs of the engineering divisions as can arrange to be present will describe in greater detail the work done in their various branches.

S. E. TINKHAM, *Secretary.*

MEMBERS ENGAGED IN WAR WORK.

Will members of the Society who are in any branch of the U. S. military or naval service, or who are doing war work in any department of the government, kindly send to the Secretary their correct titles and addresses? It seems advisable to maintain at Society headquarters a list of members so engaged, and the Secretary would appreciate being kept informed along these lines.

PAPERS IN THIS NUMBER.

"History of the Boston Dry Dock." James W. Rollins.
"The Discharge Integrator." Charles H. Pierce.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

Boston, June 6, 1917. — A regular meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in the Society Library, Tremont Temple.

The meeting was called to order at 7.50 o'clock by the Chairman, Frank A. Marston. The records of the annual meeting were approved as printed in the April Journal.

The Chairman stated that the Clerk of the Section, Arthur D. Weston, would be unable to serve for several months because of his appointment to the Officers' Reserve Training Camp. John P. Wentworth was elected Clerk pro tem. during Mr. Weston's absence.

The speaker of the evening was Prof. Robert Spurr Weston, who gave a very interesting talk on the "Biological Self-Purification of Coweeset River, Brockton, Mass." The talk was illustrated with lantern slides, prints and microscopical slides.

It was voted to extend the thanks of the Section to Professor Weston, for his interesting address.

There were twenty-two present. Meeting adjourned at 10.15 o'clock.

John P. Wentworth, *Clerk pro-tem.*

Newton, Mass., June 13, 1917. — A regular meeting of the Society was held at Norumbega Park, Newton, Mass., on Wednesday, June 13, 1917, and was called to order at 2.45 P.M. by the President. This meeting was held after a ball game and a dinner, in which the New England Water Works Association took part. There were present 31 members of the Society and

119 guests, including ladies and members of the N. E. W. W. A., a total of 150. In the absence of the Secretary, Mr. Charles W. Sherman was designated to act as Secretary.

The records of the regular meeting of May 16 were read and approved.

The acting Secretary reported for the Board of Government that it had elected the following applicants for membership in the various grades:

Members — Messrs. Anthony S. Coombs, William James Long, Walter Thomas Palmer and Louis J. St. Amand.

Juniors — Messrs. Laurence Joslyn Phillips and Hyman Benjamin Ullian.

Associate — Mr. Arthur Frederick Probst.

The acting Secretary also reported for the Board of Government that the letter ballot for endorsement of the formation of an engineer regiment in the Massachusetts National Guard had been canvassed, as directed by the meeting of May 16; that 296 members had voted in the affirmative and 8 in the negative, and that the resolution was adopted.

The question on the motion "that a sum not exceeding $500 be appropriated from the income of the Permanent Fund for the improvement and furnishing of the Society rooms," which was voted at the May meeting, was put a second time, as required by the By-Laws, and was passed, 23 members voting in the affirmative and none in the negative.

The President announced the death of Franklin B. Locke, a member of the Society, which occurred May 11, 1917. On motion, the President was instructed to appoint a committee to prepare a memoir of Mr. Locke. As such committee the President has appointed Messrs. Richard A. Hale and George F. Swain.

Mr. William S. Johnson moved the adoption of the following resolutions:

War Prohibition.

Whereas, on account of a state of war, it is necessary that this country conserve its sources of food supply to the utmost; and

Whereas, immense quantities of grain, molasses and other food products are now used in the manufacture of distilled and fermented liquors;

Be it resolved, that the members of the Boston Society of Civil Engineers present at this meeting favor such Congressional action as will result in the prohibition of the manufacture and sale of distilled and malt liquors in the United States during the continuance of the war; and

Be it resolved, that copies of this resolution be sent to the President of the United States and to the Senators and Representatives who represent the Commonwealth of Massachusetts in Congress.

The motion was seconded by Mr. Sanford E. Thompson, and was carried unanimously. On motion of Mr. Thompson, it was voted that in forwarding copies of this resolution, it should be noted that it was passed by a unanimous vote.

Adjourned at 2.55 P.M.

CHARLES W. SHERMAN, *Acting Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[September 4, 1917.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

Goldman, Sam, Detroit, Mich. (Age 21, b. Volkinsk, Russia.) Student for three years at Y. M. C. A. Coöperative Engrg. School. In 1915, inspector with Boston Transit Comm. on Dorchester Tunnel; in 1916, draftsman with Massachusetts Highway Comm.; from 1916 to 1917, draftsman with New England Structural Co.; from 1917 to date, in private practice as civil engineer, specializing in city surveying. Refers to C. S. Ell, A. E. Kleinert, Jr., A. M. Lovis, P. C. Nash, A. F. Probst and Max Silverman.

Kendall, Theodore Reed, Jersey City, N. J. (Age 27, b. Boston, Mass.) Received degree of S.B. from Harvard College, 1912, and degree of M.C.E. from Harvard Graduate School of Applied Science, 1914. In 1915, employed by Prof. G. C. Whipple; from January, 1916, to March, 1917, employed by Panama Canal as chemist in charge of Agua Clara Filtration Plant, Gatun, Canal Zone; from March, 1917, to date, engineering editor *The American City*, New York, N. Y.; elected an associate, November 17, 1915, and now desires to be transferred to grade of member. Refers to Frederic Bonnet, Jr.; H. J. Hughes, L. J. Johnson, F. A. Marston, R. S. Weston and G. C. Whipple.

Lapham, Samuel, Jr., Akron, Ohio. (Age 25, b. Charleston, S. C.) Graduate of College of Charleston, 1913, degree of A.B., and of Mass. Inst. of Technology, 1916, architectural engineering course, degree of S.B. From June to September, 1914, draftsman with D. C. Barbot, architect, Charleston; from June to November, 1916, with Brigham, Coveney & Bisbee, architects, Boston; from July, 1916, to 1917, architect for Gainor & Burton, contractors, Charleston, on Chicora Place development project; from November, 1916, to February, 1917, with Fay, Spofford & Thorndike, Boston; is now with Carmichael Const. Co., Akron, Ohio. Refers to C. R. Berry, F. H. Fay, R. W. Horne, W. H. Lawrence, C. M. Spofford and S. H. Thorndike.

Leavitt, Albert Joseph, Foxboro, Mass. (Age 27, b. Boston, Mass.) Student at Franklin Inst., 1910 to 1913, mechanical and electrical engineering course. From 1905 to 1908, with F. O. Thaxter, electrical contractor; from 1908 to 1909, with T. W. Byrne, electrical contractor; from 1909 to 1910, with E. C. Lewis, electrical contractor; from 1910 to 1911, with East Boston Gas Co. on construction work; from 1911 to 1912, with American Voting Machine Co. on machine design; from 1912 to 1913, with Holtzer-Cabot Co.; from 1913 to 1914, with F. A. Hartshorn, Walpole; from 1914 to 1915, with Phillipsdale Paper Co., Phillipsdale, R. I.; in 1916, with Stone & Webster Engrg. Corp'n; from October, 1916, to date, with White, Weld Co. Refers to W. A. Brown, R. O. Delano, H. W. Hayward and H. S. Kimball.

LIST OF MEMBERS.

ADDITIONS.

Coombs, Anthony S. .... 73 Harvard Ave., Allston, Mass.
Long, William J. .... 46 Front St., Woonsocket, R. I.
Palmer, Walter T. .... 43 Hobson St., Faneuil, Mass.
Phillips, Laurence J. .... 70 Devonshire St., Boston, Mass.

CHANGES IN ADDRESS.

Allard, Thomas T. .... 912 Liberty Bldg., Philadelphia, Pa.
Boas, Benjamin .... Care Colt Patent Fire Arms Co., Hartford, Conn.
Bowers, George W.,
Care Constructing Quartermaster, Chillicothe Cantonment, Chillicothe, Ohio
Brown, C. Leonard .... 1339 15th St., N. W., Washington, D. C.
Eberhard, Walter C. .... 138 Poplar St., Roslindale, Mass.
Elkins, Clayton R., Lieut., Public Works Dept., Navy Yard, Norfolk, Va.
Hammond, N. LeRoy .... 82 Walpole St., Norwood, Mass.
Holway, William R. .... Office of City Chemist, Alliance, Ohio
Hubbard, Carl P. .... Sergeant, Co. D, 1st Engrs., U. S. Nat'l Army
Mead, Royal L. .... Box 182, Jackson, Mich.
Moore, Lewis E.,
Capt., 3d Co., Engrs. Training Camp, American Univ., Washington, D. C.
Snow, Leslie W.,
Lieut., Gun Div., Office Chief of Ordnance, 1330 F St., Washington, D. C.
Stenberg, Thornton R., ... Co. 5, 1st N. E. Regiment, Plattsburg, N. Y.
Home address, 23 Burncoat St., Worcester, Mass.
Sumner, Merton R. .... Radnor Mills, Elkton, Md.
Waring, Charles T., Captain, Aviation Section, Signal Officers' Reserve Corps, 1015 North Main St., Dayton, Ohio
Webb, DeWitt C., Public Works Office, U. S. Navy Yard, Philadelphia, Pa.
Wells, Charles E. .... 32 Prospect St., White Plains, N. Y.
Worcester, Robert J. H.,
Eighth Co., 17th Provisional Regiment, Plattsburg Barracks, N. Y.

DEATH.

Miller, Stanley A. .... May 13, 1917

EMPLOYMENT BUREAU.

The Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for

furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

402. Age 28. Student for two years at Cornell University, civil engineering course. Experience consists of work on two sewage disposal plants. Desires position as transitman, levelman or rodman.

403. Age 29. Took special course at Harvard. Has had ten years' experience along engineering lines. Desires position as superintendent of construction or as draftsman, designer or detailer on architectural design.

404. Age 27. Graduate of Tufts College, 1912, civil engineering course. Experience includes four and one-half years on railroad work as transitman and assistant to supervisor of track; and one year as sub-foreman on form building and general concrete work; has also had some experience as timekeeper and draftsman. Desires position as transitman or as assistant superintendent or foreman on construction work.

405. Age 28. Student for two years at Case School, Cleveland, Ohio; graduate of Mass. Inst. of Technology, 1912, degree of B.S. Has had about four years' experience as rodman and transitman on general survey work, two months on right-of-way work for transmission line, and two months as inspector on highway work. Desires position as transitman. Minimum salary desired, $85 per month.

406. Age 36. Graduate of Mechanic Arts High School, Boston; student for one year at Mass. Inst. of Technology and for three years at Franklin Union. Has had nearly fourteen years' experience, including one year as rodman, two years as transitman on railroad location and property surveys, one year on construction work (Charles River Basin), four years in bureau of topography, three years on town work and private surveys, and two years as draftsman and inspector on concrete work. Desires position as draftsman or chief-of-party. Salary desired, $25 per week.

407. Age 40. Has had about seven years' experience as resident engineer on railroad construction. Desires position as engineer in charge of outside construction or as inspector.

408. Age 62. Has had wide experience along engineering lines, including two years as U. S. Asst. Engr., chiefly on harbor work; eight years on municipal work, and twenty-two years as assistant engineer for prominent railroads. Salary desired, $100 per month.

LIBRARY NOTES.

Recent Additions to the Library.

On Military Engineering and Related Subjects.

Individual and Combined Military Sketching. Edwin T. Cole and Edwin R. Stuart.

National Service Handbook. U. S. Committee on Public Information.

Trench Warfare. J. S. Smith.

U. S. Government Reports.

Annual Report of Director of Office of Public Roads and Rural Engineering.

Antimony, Arsenic, Bismuth, Selenium and Tellurium in 1915. Frank L. Hess.

Artificial Gas and By-Products in 1915. C. E. Lesher.

Automobile Registrations, Licenses and Revenues in United States, 1916.

Cleveland Gas Field, Cuyahoga County, Ohio, with Study of Rock Pressure. G. Sherburne Rogers.

Cobalt, Molybdenum, Tin, Titanium, Tungsten, Radium, Uranium and Vanadium in 1915. Frank L. Hess.

Cotton Production in United States, Crop of 1916.

Crossties Purchased and Treated in 1915. Arthur M. McCreight.

Drainage of Irrigated Farms. R. A. Hart.

Gold and Silver in 1915. H. D. McCaskey and J. P. Dunlop.

Nursery Practice on National Forests. C. R. Tillotson.

Oil Resources of Black Shales of Eastern United States. George H. Ashley.

Properties of Calcium Silicates and Calcium Aluminate Occurring in Normal Portland Cement. P. H. Bates and A. A. Klein.

Results of Physical Tests of Road-Building Rock in 1916, including All Compression Tests. Prévost Hubbard.

Seasoning of Wood. Harold S. Betts.

Status and Value of Farm Woodlots in Eastern United States. E. H. Frothingham.

Tests of Western Yellow Pine Car Sills, Joists and Small Clear Pieces. C. W. Zimmerman.

Use of Mean Sea Level as Datum for Elevations. E. Lester Jones.

Utilization of Ash. W. D. Sterrett.

Water-Supply Paper 400-E.

State Reports.

Massachusetts. Annual Report of Public Service Commission for 1916, Vol. I.

Massachusetts. Annual Report of Commission on Waterways and Public Lands for 1916.

Massachusetts. Annual Report of Metropolitan Park Commissioners for 1916.

Massachusetts. Annual Report of Metropolitan Water and Sewerage Board for 1916.

Massachusetts. Annual Report of Gas and Electric Light Commissioners for 1916.

New Jersey. Annual Report of Commissioner of Public Roads for 1916.

New Jersey. Annual Report of Department of Conservation and Development for 1916.

New York. Annual Report of Public Service Commission for First District for 1915, Vols. I and II.

New York. Annual Reports of State Engineer and Surveyor for 1915 and 1916. 4 vols.

Pennsylvania. Annual Reports of Commissioner of Health for 1913 and 1914. 4 vols.

Municipal Reports.

Albany, N. Y. Annual Report of Bureau of Water for 1916.

Bangor, Me. Annual Report of Water Board for 1916.

Boston, Mass. Reports and Communications of Finance Commission, 1917, Vol. XII.

Brockton, Mass. Annual Report of City Engineer for 1916.

Brockton, Mass. Annual Report of Sewerage Commissioners for 1916.

Cambridge, Mass. Annual Report of City Engineer for 1915–16.

Concord, N. H. Annual Report of Water Commissioners for 1916.

Erie, Pa. Annual Report of Commissioners of Water Works for 1916.

Fitchburg, Mass. Semi-Annual Reports of Sewage Disposal Commission for 1916.

Haverhill, Mass. Annual Report of Water Commissioners for 1916.

Leominster, Mass. Annual Report of Water Commissioners for 1916.

Lynn, Mass. Annual Report of Commissioner of Water and Water Works for 1916.

Marlborough, Mass. Annual Report of Water and Sewage Commission for 1916.

New Orleans, La. Semi-Annual Report of Sewerage and Water Board, December, 1916.

New York, N. Y. Annual Report of Department of Water Supply, Gas and Electricity for 1916.

Philadelphia, Pa. Report upon Proposal of Philadelphia Rapid Transit Company for Equipment and Operation of City-Built High-Speed Lines. Gift of H. S. Knowlton.

Pittsfield, Mass. Annual Report of Board of Public Works for 1916.

Plainfield, N. J. Annual Report of City Officers for 1916.

Providence, R. I. Annual Report of City Engineer for 1916.

Revere, Mass. Annual Report of Public Works Department for 1916.

St. Louis, Mo. Annual Report of Water Commissioner for 1916.

St. Paul, Minn. Annual Report of Water Commissioners for 1916.

Salt Lake City, Utah. Annual Reports of Officers for 1916; Appropriation Budget for 1917.

Somerville, Mass. Annual Reports for 1916.

Taunton, Mass. Annual Report of Water Commissioners for 1916.

Waltham, Mass. Annual Reports of City Engineer and Superintendent of Water Works and Sewers for 1916.

Worcester, Mass. Annual Report of Superintendent of Sewers for 1916.

Miscellaneous.

Canada, Department of Mines: Annual Report of Mineral Production of Canada during Calendar Year 1915; Preliminary Report of Mineral Production of Canada during Calendar Year 1916; Report of Building and Ornamental Stones of Canada, Vol. IV, by Wm. A. Parks; Coal Fields and Coal Industry of Eastern Canada, by Francis W. Gray; Value of Peat Fuel for Generation of Steam, by John Blizard.

Institution of Civil Engineers (London). Minutes of Proceedings, Vol. CCII.

National Board of Fire Underwriters: Reports and bulletins on the following cities: Allentown, Pa.; Altoona, Pa.; Baltimore, Md.; Binghamton, N. Y.; Chicago, Ill.; Columbus, Ga.; Detroit, Mich.; Easton, Pa.; Erie, Pa.; Hagerstown, Md.; Hamtramck, Mich.; Hartford, Conn.; Highland Park, Mich.; Lancaster, Pa.; Minneapolis, Minn.; Newcastle, Pa.; New York, N. Y.; Newport, R. I.; Norfolk, Va.; Pawtucket and Central Falls, R. I.; Phœnix, Ariz.; Portland, Ore.; Richmond, Va.; St. Paul, Minn.; Syracuse, N. Y.; Taunton, Mass.; Toledo, Ohio; Washington, D. C.; Waterbury, Conn.; Wilkesbarre, Pa.

Portland Cement Association: Concrete Septic Tanks; Concrete Ships; Concrete Tile for Land Drainage; Protecting Concrete Work Done in Warm Weather; Simple Forms for Concrete; Tennis Every Day on Concrete Courts; Why Build Fireproof?

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

Commonwealth of Massachusetts.—Metropolitan Water and Sewerage Board. — *Water Works.* — On July 28, 1917, a contract was awarded to Fred T. Ley & Co., Inc., of Springfield, Mass., for the sum of $74 477, for the construction of a three-phase, 66 000-volt transmission line, 15.6 miles long, between the Wachusett power station at Clinton and the Sudbury power station at Southborough, Mass.

Metropolitan Water and Sewerage Board. — *Sewerage Works.* — Work in progress: *South Metropolitan System.* — Sections 98–102, Wellesley Extension.

North Metropolitan System. — Section 1, outfall extension at Deer Island.

Alteration Work. — Change in Charles River Sewer in Brighton to accommodate City of Boston surface drain.

Metropolitan Park Commission. — *Old Colony Parkway.* — Construction of a temporary bridge across the Neponset River between Boston and Quincy is in progress.

Old Colony Parkway. — The work of dredging new channel in Neponset River at new location of Neponset Bridge is in progress.

City of Boston. — Public Works Department, Highway Division, Paving Service. — Work is in progress on the following streets:

South Boston.

(Work being done by department forces.)

B St.,	from West 6th St. to West 7th St.	Macadam.
E St.,	from West 6th St. to West 7th St.	Granite block.

(Work being done by contract.)

W. Broadway,	from Dorchester Ave. to E St.	Asphalt. (Connell.)

East Boston.

(Work being done by department forces.)

Meridian St.,	from Condor St. to Eutaw St.	Macadam.

(Work being done by contract.)

Neptune Rd.,	from Bennington St. to B., R. B. & L. R. R.	Asphalt.	(Donovan.)

Charlestown.

(Work being done by department forces.)

Water St.,	near Wapping St.	Granite block.

Brighton.

(Work being done by department forces.)

Washington St.,	from Market St. to Fairbanks St.	Macadam.
Beacon St.,	from Cleveland Circle to Reservoir Rd.	Concrete.

(Work being done by contract.)

Turner St.,	from Washington St. to Faneuil St.	Asphalt.	(O'Keefe.)
Cummings Rd.,	from Commonwealth Ave. 855 ft. n'ly.	Asphalt.	(Coyle.)
Glencoe St.,	from North Beacon St. to Garden St.	Asphalt.	(O'Neil.)
Waldo Terrace,	from Washington St. to Henshaw St.	Asphalt.	(O'Keefe.)
South St.,	from Chestnut Hill Ave. to Commonwealth Ave.	Asphalt.	(O'Keefe.)
Parkland St.,	from Winship St. to Academy Hill Rd.	Asphalt.	(O'Keefe.)

West Roxbury.

(Work being done by department forces.)

Pond St.,	from May St. to Brookline line.	Macadam.
Hyde Park Ave.,	from Walk Hill St. to Ashland St.	Macadam.
Cornell St.,	from Washington St. to Bellevue Ave.	Edgestone.

(Work being done by contract.)

Cornell St.,	from Orange St. to Colberg Ave.	Bituminous macadam.	(Reed.)
Richwood St.,	from Centre St. to Montview St.	Asphalt.	(Cahill.)
Perham St.,	from Vermont St. to railroad.	Asphalt.	(Reed.)
Saville St.,	from Park St. to Stratford St.	Asphalt.	(Reed.)
Seymour St.,	from Brown Ave. to Canterbury St.	Artificial walks.	(Corcoran.)
Brown Ave.,	from Poplar St. to Blakemore St.	Artificial walks.	(Corcoran.)

Dorchester.

(Work being done by department forces.)

Adams St.,	from Dorchester Ave. to Leonard St.	Granite block.
Goodale Rd.,	from Wellington Hill to Blue Hill Ave.	Edgestone.
Trull St.,	from Hancock St. to Bellevue St.	Macadam.
Blue Hill Ave.,	from Talbot Ave. to Mattapan Sq.	Macadam.
Linden St.,	from Dorchester Ave. to Freeport St.	Macadam.

(Work being done by contract.)

Southwick St.,	from Neponset Ave. to Freeport St.	Asphalt. (J. Murphy.)
Rowell St.,	from Hancock St. to Cushing Ave.	Bituminous macadam. (J. Murphy.)
Rugby Rd.,	from Randolph St. to Oakland St.	Asphalt. (Cahill.)
Blake St.,	from Randolph Rd. to Hyde Park line.	Asphalt. (Cahill.)
Hill Top St.,	from Granite Ave. to Hallett St.	Bituminous macadam. (J. Murphy.)
Neponset Ave.,	from King St. to Boutwell St.	Artificial walk. (Hayden.)
Dorchester Ave.,	from Freeport St. to Park St.	Artificial walk. (McMorrow.)
Rosemont St.,	from Adams St. to Gustine St.	Artificial walk. (Hayden.)
King St.,	from Neponset Ave. to Adams St.	Artificial walk. (Hayden.)
Dorchester Ave.,	from Peabody Sq. to Washington St.	Granite block. (Connell.)
Dorchester Ave.,	from Savin Hill Ave. to Freeport St.	Granite block. (Hasson.)
Norfolk St.,	from Corbet St. to Blue Hill Ave.	Asphalt. (Coyle.)
Adams St.,	from King Sq. to Ashmont St.	Artificial walks. (Hayden.)

ROXBURY.

(Work being done by department forces.)

Mt. Pleasant Ave.,	from Dudley St. to Vine St.	Macadam.
Warren St.,	from Townsend St. to Grove Hall.	Macadam.
Washington St.,	from Dimock St. to Marcella St.	Macadam.
Waumbeck St.,	from Warren St. to Crawford St.	Macadam.
Montebello Rd.,	from Marmion St. to Brookside St.	Macadam.

(Work being done by contract.)

Seaver St.,	from Blue Hill Ave. to Walnut Ave.	Asphalt. (Magner.)

CITY PROPER.

(Work being done by contract.)

Albany St.,	from Dover St. to Northampton St.	Granite block. (Hasson.)
Haymarket Sq.,		Granite block. (Sheehe.)
Fruit St.,	from Charles St. to Blossom St.	Asphalt. (Magner.)
North Grove St.,	from Cambridge St. to Fruit St.	Asphalt. (Magner.)
Washington St.,	from Haymarket Sq. to Elm St.	Granite block. (Sheehy-Galvin.)
Beacon St.,	from Tremont St. to Park St.	Granite block. (Sheehe.)

New York, New Haven and Hartford Railroad. — CONSTRUCTION DEPARTMENT. — *South Boston Cut Improvement.* — Active construction work of enlarging South Boston cut to Boston Freight Terminal to accommodate four tracks instead of two, and rebuilding of eleven overhead highway bridges so as to span four tracks instead of two, to be started immediately.

Southampton Street Engine Facilities. — Work consisting of new 39-stall engine house, 95-ft. turntable, ash pits, boiler house, office building, and water tank, practically completed with the exception of some minor work. Necessary trackage, etc., progressing.

Vol. IV OCTOBER, 1917 No. 8

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, OCTOBER 17, 1917,

at 7.45 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Henry I. Harriman, president of the New England Power Company, will read a paper entitled, "Water Powers of New England." The paper will deal not only with the water powers of the New England Power Company, but with other hydro-electric developments and economic questions that underlie their construction and utilization.

The paper will be illustrated with lantern slides.

S. E. TINKHAM, *Secretary.*

PAPERS IN THIS NUMBER.

"Aviation as Applied to the Navy." George D. Murray.

"Continuous Beams of Unequal Spans." Frank S. Bailey.

"Classification of Civil Engineers under the Civil Service." Report of the Committee.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

REPORT OF THE MILITARY COMMITTEE ON EQUIPMENT FUND FOR THE 101ST UNITED STATES ENGINEERS.

Boston, Mass., October 2, 1917.

To the Boston Society of Civil Engineers:

At a regular meeting of the Society held May 16, 1917, the Board of Government recommended the adoption of the following resolution:

Whereas, engineers and engineer troops are of prime importance in modern warfare, and

Whereas, the organization of engineer troops is particularly a subject for coöperation on the part of societies of engineers, and

Whereas, a regiment of engineers is now being organized in the Massachusetts National Guard, by the transformation and enlargement of the First Corps of Cadets; therefore

Be it resolved, that the Boston Society of Civil Engineers endorses the formation of such regiment of engineers, *and pledges to it its support and assistance.*

This resolution was unanimously adopted by the meeting, and, in accordance with the provisions of the constitution, was submitted to the full membership by letter ballot.

At the regular meeting held on June 13, 1917, the letter ballot was canvassed, with the result that 296 members voted in the affirmative and 8 in the negative.

In order properly to carry out the purport of this resolution, it was suggested that our committee take some substantial action which would make manifest the sincerity of purpose embodied in the resolution. Accordingly the committee decided to solicit voluntary subscriptions from the members of the Society, looking to the creation of a fund which should be available for the purpose of necessary or desirable equipment not customarily supplied by the War Department and which might add to the efficiency or comfort of the men in this organization.

A circular was mailed to the membership of the Society on June 29, 1917, followed by a second appeal on July 18, 1917, outlining the necessity for such action and requesting subscriptions for the creation of such a fund, the disposition of the fund to be determined by the Board of Government of the Society. As a result of these appeals, a total of $2 220 has been received by the Secretary, divided as follows:

5 subscriptions of	$100.00 each.
4 subscriptions of	50.00 each.
11 subscriptions of	25.00 each.
9 subscriptions of	20.00 each.
4 subscriptions of	15.00 each.
64 subscriptions of	10.00 each.
1 subscription of	7.50
58 subscriptions of	5.00 each.
2 subscriptions of	4.00 each.
3 subscriptions of	3.00 each.
1 subscription of	2.50
15 subscriptions of	2.00 each.
18 subscriptions of	1.00 each.
195 Total amount,	$2 220.00

Early in the month of August a conference was had with Colonel Bunnell of the Engineer Regiment, in order to learn if possible what articles of special equipment appealed to him as being most desirable for the needs of the regiment. He very frankly stated that there was a great variety of articles which were not included in the regular equipment of an engineer regiment, the possession of which would add very materially to the efficiency of his organization, but in the absence of a definite knowledge of the particular class of service to which his regiment would be assigned, he could not then make an intelligent selection. He suggested, however, in view of this uncertainty, that perhaps the fund could be better applied to its purpose if it were turned over intact to the regiment, to be expended as and when future circumstances might dictate. Colonel Bunnell's suggestion was submitted to the Board of Government on August 24, and after discussion the Board voted to instruct the Secretary to transfer the money in the fund to Colonel Bunnell, to be expended as his judgment might dictate.

The following correspondence taken from the files of the Society is self-explanatory:

BOSTON SOCIETY OF CIVIL ENGINEERS.

BOSTON, August 27, 1917.

COL. GEO. W. BUNNELL,
101ST REGIMENT, U. S. ENGINEERS,
CADET ARMORY, COLUMBUS AVE., BOSTON, MASS.

Dear Sir, — At a meeting of the Board of Government of the Boston Society of Civil Engineers, held on August 24, 1917, the following vote was passed:

> "*Voted*, that the equipment fund for the Massachusetts Engineer Regiment now on hand, or which may be contributed later, be turned over to Colonel Bunnell of the 101st Regiment, United States Engineers, to purchase such emergency equipment for the benefit of the regiment as his judgment may dictate."

There is now on deposit in the Old Colony Trust Co., to the credit of this fund, the sum of $2 200, and I have the pleasure of enclosing a check for this sum payable to your order.

As you already know, this fund was contributed by members of the Society for the purpose of furnishing the regiment with certain equipment not ordinarily supplied by the War Department, which would add to the efficiency of your organization.

After a conference with you, the chairman of our Committee on Military Affairs, Mr. Charles R. Gow, reported to the Board of Government of the Society that under present conditions it seemed advisable to turn the fund over to the regiment for such expenditure as you should deem to be for its best interests, rather than to purchase special equipment which later might not be found to be useful.

Extending to the officers and men of the Engineer Regiment the best wishes of the Boston Society of Civil Engineers, I am

Very truly yours,

(Signed) S. E. TINKHAM, *Secretary.*

FIRST CORPS CADETS, 1ST REGIMENT MASS. ENGINEERS, N. G.

COLUMBUS AVENUE, BOSTON, August 29, 1917.

S. E. TINKHAM, Esq., *Secretary,*
BOSTON SOCIETY OF CIVIL ENGINEERS,
BOSTON, MASS.

My dear Mr. Tinkham, — I take pleasure in acknowledging your favor of the 27th instant, inclosing check to my order from the Military Equipment Fund of the Society for twenty-two hundred dollars.

On behalf of the regiment I wish to express its sincere thanks for this gift, and particularly for the spirit that prompted it. It is certain that the money itself, which is to be used to purchase such emergency equipment for the benefit of the regiment as my judgment may dictate, gives the regiment a certain advantage over other engineer regiments, and will better enable it to perform its duty in the service of our country in such a way, or to such extent, as will make all of us proud of its record.

The officers and men of the regiment thank the Boston Society of Civil Engineers for its good wishes, and for the token of these good wishes which has been expressed in this substantial way.

Very sincerely yours,

(Signed) GEO. W. BUNNELL,
Colonel, 101st U. S. Engineers.

Since the date of Secretary Tinkham's letter, there has been contributed the additional sum of $20 which, in accordance with the provisions of the vote of the Board of Government, will also be turned over to Colonel Bunnell.

For the Committee on Military Affairs,

CHARLES R. GOW, *Chairman.*

MINUTES OF MEETING.

Boston, September 19, 1917. — A regular meeting of the Boston Society of Civil Engineers was held this evening in Chipman Hall, Tremont Temple, and was called to order by Vice-President Lewis M. Hastings, at 8 o'clock. There were 140 members and visitors present.

The record of the June meeting was read and approved.

The Secretary reported for the Board of Government that it had elected to membership in the grade of member Mr. Gardner Sabin Gould, and in the grade of junior Mr. Edward Andrus Terhune, Jr., and that it had also elected to honorary membership John R. Freeman, George F. Swain, Ira N. Hollis and Howard A. Carson.

The Secretary read a communication from Mr. E. F. Rockwood, a member of the Society, and chief engineer of the New England Concrete Construction Company, requesting this Society to join with the Boston Society of Architects and the Master Builders Association in the appointment of a joint committee to prepare and submit to the next legislature a revision of the structural portion of the Boston Building Laws. On motion of Mr. Bryant, the communication was referred to the Board of Government with full powers.

The Secretary announced the death of Stanley A. Miller, a member of the Society, which occurred on May 13, 1917. By vote the Chair was requested to appoint a committee to prepare a memoir, and Mr. William H. Balch has been appointed.

Mr. Gow, for the Committee on Military Affairs, submitted a report which is printed in the October, 1917, number of the Journal of the Society.

Mr. Frank A. Barbour was then introduced and gave a most interesting account of the cantonment construction work at Camp Devens, Ayer, Mass., of which he was the supervising engineer. The talk was very fully illustrated with lantern slides.

Other speakers were Captain Edward Canfield, Jr., U.S.A., construction quartermaster; Major Glen I. Jones, sanitary officer; Mr. Frank Rogers, general manager for the Fred T. Ley

Co., the contractors for the work; and Mr. Leonard Metcalf, a member of the Society.

After passing a vote of thanks to the several speakers of the evening, for their courtesy in presenting in so interesting a manner the building of the cantonment at Ayer, the meeting adjourned at 10.30 o'clock.

S. E. TINKHAM, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[October 4, 1917.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission, and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

ALLEN, ELMER FOREST. Medford, Mass. (Age 24, b. Cliftondale, Mass.) Student for two years with International Correspondence Schools, course in surveying and mapping; is now third-year student at Northeastern College (Y. M. C. A.) Engrg. School, structural engineering course. From March, 1917, to date, draftsman with bridge department, B. & M. R. R. Refers to A. S. Coombs, C. S. Ell, J. B. Mailey and L. J. Phillips.

LOHMEYER, WILLIAM, Jr. Cambridge, Mass. (Age 22, b. Charleston, W. Va.) Graduate of Virginia Military Inst., 1912, degree of B.S.; is now senior at Mass. Inst. of Technology. Refers to J. B. Babcock, G. L. Hosmer, J. W. Howard, Dwight Porter, A. G. Robbins and C. M. Spofford.

WELLS, EDWARD PIERCE. Malden, Mass. (Age 20, b. Boston, Mass.) Student for one year at Lowell Inst. School for Industrial Foremen. Was for one year (1915) in employ of McGunigle & Taunge on underground electrical construction; has been for two years (1916 and 1917) draftsman with Aberthaw Construction Co. Refers to L. H. Allen, R. E. Parker, A. B. MacMillan and F. S. Wells.

LIST OF MEMBERS.

HONORARY MEMBERS.

(Elected September 19, 1917.)

CARSON, HOWARD ADAMS.
FREEMAN, JOHN RIPLEY.
HOLLIS, IRA NELSON.
SWAIN, GEORGE FILLMORE.

CHANGES IN ADDRESS.

ATWOOD, THOMAS C. .... 485 Edgewood Ave., New Haven, Conn.
BALCH, WILLIAM H. .... Capt., E. O. R. C., Am. Univ., Washington, D. C.
BARNES, ARTHUR B. .... 650 Hanover St., Fall River, Mass.
BURLEIGH, WILLARD G. .... Corp., 25th Engrs., Ayer, Mass.
CASEY, JOHN J. .... 81 Moreland St., Roxbury, Mass.
COREY, KENNETH T. .... 19 Lenox St., Springfield, Mass.
COWAN, HENRY E. .... East Milton, Mass.
FOSTER, HOWARD L. .... 17 Paul St., Watertown, Mass.
GERRISH, HERBERT T., Lieut., Camp American University, Washington, D. C.
HANF, FRANK S. .... 2d Lieut., 305th Engrs., Camp Lee, Petersburg, Va.
HUBBARD, CARL P. .... Sergt., Co. D, 11th Engr. Regiment,
Care of American Expeditionary Force, Paris, France.
JERRETT, ROBERT .... 115 Beckwith St., Elmwood Sta., Providence, R. I.
KATZ, HARRY L.,
Care of Supervising Engr.'s Office, Camp Meade, Baltimore P. O., Md.
LEONARD, JOSEPH F. A. .... 2d Lieut., E. O. R. C., 102d Engrs., U. S. A.,
Camp Wadsworth, Spartanburg, S. C.
MAYNARD, FORREST J. .... 22 Broadway, Watertown, Mass.
McNULTY, RICHARD J. ...... Care of Charles F. Berrill, No. Lexington, Mass.
MEADE, ROYAL L. .... 10 and 12 Pearson St., Chicago, Ill.
NASH, PHILIP C.,
Lieut., E. O. R. C., U. S. A., Am. Univ. Training Camp, Washington, D. C.
RAND, ROBERT .... Lieut., j. g., U. S. Naval Reserve Force,
Communication Office, Bldg. No. 24, Navy Yard, Boston, Mass.
SAVILLE, THORNDIKE .... 53 No. Beacon St., Hartford, Conn.
SEARS, CALVIN C. .... 3 Bryan Ave., Branford, Conn.

SKILLIN, FRED B.,
Care of J. W. Zisgen, Interstate Commerce Comm., Washington, D. C.
VESPER, ROBERT A. . . . . 243 Harvard Ave., Allston, Mass.
WADE, W. NEWELL . . . . 42 Park Vale Ave., Suite 2, Allston, Mass.
WARING, CHARLES T.,
Major, Signal Corps, Chamber of Commerce Bldg., Fort Worth, Tex.
WESTON, ARTHUR D. . . . . Lieut., 26th Engr. Regiment, Camp Dix, N. J.
WHITNEY, RALPH E. . . . . Lieut., 98 Mountfort St., Suite 6, Boston, Mass.
YOUNG, ERVING M. . . . . Meade Branch, Baltimore P. O., Md.

DEATH.

PIERCE, FRANK A. . . . . August 7, 1917

LIBRARY NOTES.

Recent Additions to the Library.

On Military Engineering and Related Subjects.

Naval Architecture. Cecil H. Peabody.

Practical Shipbuilding, 2 vols. A. Campbell Holms.

U. S. Government Reports.

Analyses of Coals Purchased by the Government during Fiscal Years 1908–1915. George S. Pope.

Asbestos in 1916. J. S. Diller.

Asphyxiation from Blast-Furnace Gas. Frederick H. Willcox.

Chemical Relations of Oil-Field Waters in San Joaquin Valley, California. G. Sherburne Rogers.

Contributions to Economic Geology, 1916: Part I. — Metals and Non-metals except Fuels. F. L. Ransome and Hoyt S. Gale. Part II. — Mineral Fuels. David White and others.

De Soto-Red River Oil and Gas Field, Louisiana. George Charlton Matson and Oliver Baker Hopkins.

Determination of Nitrogen in Substances Used in Explosives. W. C. Cope and Guy B. Taylor.

Economic Geology of Gilpin County and Adjacent Parts of Clear Creek and Boulder Counties, Colorado. Edson S. Bastin and James M. Hill.

Enrichment of Ore Deposits. William Harvey Emmons.

Fuel Briquetting in 1916. C. E. Lesher.

Lithium Minerals in 1916. Waldemar T. Schaller.

Methods of Testing Natural Gas for Gasoline Content. G. A. Burrell and G. W. Jones.

Mining Industry in Territory of Alaska during Calendar Year 1905. Sumner S. Smith.

Motor Gasoline: Properties, Laboratory Methods of Testing, and Practical Specifications. E. W. Dean.

Our Mineral Supplies. J. S. Diller and others.

Oxygen Mine Rescue Apparatus and Physiological Effects on Users. Yandell Henderson and James W. Paul.

Occurrence and Mitigation of Injurious Dusts in Steel Works. J. A. Watkins.

Organizing and Conducting Safety Work in Mines. Herbert M. Wilson and James R. Fleming.

Physical and Chemical Properties of Gasolines Sold throughout United States during Calendar Year 1915. W. F. Rittman and others.

Pine Trees of Rocky Mountain Region. George B. Sudworth.

Platinum and Allied Metals in 1916. James M. Hill.

Primary Volatile Products of Carbonization of Coal. Guy B. Taylor and Horace C. Porter.

Rescue and Recovery Operations in Mines after Fires and Explosions. James W. Paul and H. M. Wolflin.

Sandstone Quarrying in United States. Oliver Bowles.

Submarine and Kindred Problems. Naval Consulting Board.

Talc and Soapstone in 1916. J. S. Diller.

Tungsten Minerals and Deposits. Frank L. Hess.

Underground Latrines for Mines. Joseph H. White.

Use of Panoramic Camera in Topographic Surveying, with Notes on Application of Photogrammetry to Aërial Surveys. James W. Bagley.

Water-Supply Papers 362, 386, 391, 394, 401, 403, 405, 423, 425-A.

Wet Thiogen Process of Recovering Sulphur from Sulphur Dioxide in Smelter Gases. A. E. Wells.

Zinc and Cadmium in 1915. C. E. Siebenthal.

Municipal Reports.

Fall River, Mass. Annual Report of Watuppa Water Board for 1916.

Reading, Pa. Annual Report of Bureau of Water for 1915.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

Commonwealth of Massachusetts.—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.* — Work in progress: on portion of 66 000-volt transmission line in Clinton and Berlin.

METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.* — Work in progress: Section 98 and Section 102, Wellesley Extension, Deer Island Outfall Sewer.

Work contemplated: Section 101, Wellesley Extension, is advertised. Bids to be opened September 26, 1917.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

Old Colony Parkway. — Construction of a temporary bridge across the Neponset River between Boston and Quincy.

BOSTON TRANSIT COMMISSION. — *Dorchester Tunnel.* — The following work is in progress:

Section F. The interior finish of the station and the construction of a prepayment surface station in Broadway for the interchange of passengers between surface cars and the tunnel.

Section G. Emergency exit at the pump-well, corner of Dorchester Ave. and West 5th St.; construction of bridge over the tracks of the New York, New Haven & Hartford R. R. Co. leading to the docks; ventilating chamber and emergency exit and a section of the arch near the intersection of Dorchester Ave. and Old Colony Ave.

Section J. The interior finish of the station and the construction of a surface station for the interchange of passengers between surface cars and the tunnel.

New York, New Haven & Hartford Railroad. — Construction Department.

South Boston Cut Improvement. — Enlargement of South Boston Cut to Boston Freight Terminal to accommodate four tracks instead of two, and reconstruction of eleven overhead highway bridges so as to span four tracks instead of two, progressing.

Southampton Street Engine Facilities. — New 39-stall engine house, 95-ft. turntable, ash pits, boiler house, office building, and water tank practically completed. Necessary trackage, etc., progressing.

Boston Elevated Railway Company. — Bureau of Elevated and Subway Construction.— *Everett Extension.* — The Everett Extension of the Boston Elevated Railway Company, involving the construction of the new bridge across the Mystic River and the reconstruction of the present Malden Bridge, has advanced to the point where the steel structure on either side of the new drawbridge is completed, the railway drawbridge having been completed for about a month or more. The highway draw was put in operation for navigation on September 25; the surface cars, however, were turned over this bridge on July 22, and it has been in service for highway traffic since that time. The old draw just to the south of the new one was closed permanently September 25, and the work of dismantling immediately begun. Beyond the present elevated steel structure now erected, the foundations are completed to the point where the rapid transit lines will reach the surface of the ground, and work is under way on temporary terminal station in Everett.

At the Beacham St. Yard in Charlestown, a new inspection shop is approaching completion. This is a wooden frame structure with wire lath and cement plaster walls. It is approximately 420 ft. long and 60 ft. wide, joining directly on to the northerly end of the present brick inspection shop, which is being altered to accommodate the main line tracks of the proposed Everett Extension, passing through the southeast corner of this building.

Vol. IV NOVEMBER, 1917 No. 9

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, NOVEMBER 21, 1917,

at 7.45 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Major George C. Whipple, President of the Society, will give an informal account of his journey to Russia as a member of the American Red Cross Mission.

Business of the Meeting. — To act on the following amendment to By-Law 5, submitted by members of former Nominating Committees:

Section 5 of the By-Laws to be amended to read as follows:

5. NOMINATING COMMITTEE AND ELECTION OF OFFICERS.

Whenever officers of the Society are to be elected by ballot, nominations shall be made by a Nominating Committee of nine, of whom three shall be the three latest Past Presidents who continue to be members of the Society and are not members of the Board of Government, and six shall be elected by ballot. *At the annual meeting in 1918, six members of the Nominating Committee shall be elected in accordance with the provisions of the existing By-Laws governing the elections of officers, except that only twelve candidates shall be nominated; the three candidates receiving the highest number of votes to serve two years; the three receiving the next highest number of votes to serve one year; there-*

after,* three members of the Nominating Committee shall be elected at each annual meeting to serve two years each.

The Nominating Committee shall organize and act under its own rules. It may make nominations whether at the time it consists of nine members or of less, but the approval of at least six members of the Nominating Committee shall be required for a nomination.

The Nominating Committee shall prepare a list of its nominations for the officers to be elected at the annual election, and the Secretary shall mail this list to each member of the Society at least nine weeks before the annual meeting. An additional nomination for any office may be made by any twenty-five members of the Society who sign a nomination paper to that effect and file it with the Secretary at least six weeks before the date of the annual meeting. The Secretary shall print no nomination on any list or ballot until he has received notice in writing that the nomination is made with the knowledge and consent of the nominee. At least four weeks before the day of the annual meeting, letter-ballots shall be sent by the Secretary to each member of the Society, bearing the nominations made by the Nominating Committee, and also any which have been received on nomination papers as above provided, which latter nominations shall be distinguished in some convenient way from those made by the Nominating Committee. The ballot shall state the hour at which polls will close on the day of the annual meeting.

When returned to the Secretary, each ballot shall be enclosed in two envelopes, the inner one to be blank, and the outer one to be endorsed by the member's signature. The President shall appoint two tellers who shall canvass all ballots, and the result shall be announced at the annual meeting.

Of the candidates for any office at the election at the annual meeting, the one having the largest number of legal votes by letter-ballot shall be elected. Should there be a failure to elect any officer on account of a tie, the meeting shall proceed to elect such officer by ballot from among the candidates so tied, a majority of the votes cast being required to elect.

At any meeting of the Society, a vacancy for the unexpired term of an elected officer or a member of the Nominating Committee may be filled by ballot, provided the Nominating Committee gives notice in the call for the meeting of its nomination

* The preceding words beginning "At the annual meeting" shall be effective as an amendment of the By-Laws only from the date of passage until after the annual meeting in 1918. The remainder of these amendments shall go into effect after the annual meeting in 1918.

or nominations for such vacancy, a majority of the votes cast at the meeting being necessary to elect.

Whenever a President, Vice-President, Secretary or Treasurer is to be elected, the Nominating Committee shall nominate one candidate for each office to be filled. Whenever a Director or a member of the Nominating Committee is to be elected, the Nominating Committee shall nominate two candidates for each such office to be filled. Ballots shall provide space for the writing or pasting in of additional names by the voters.

S. E. TINKHAM, *Secretary*.

PAPERS IN THIS NUMBER.

Discussion of "History and Present Status of the Concrete Pile Industry."

"Lines and Grades in Tunnels of Small Diameter." Henry B. Pratt.

Memoir of Deceased Member.

CURRENT DISCUSSION.

Paper.	Author.	Published.	Discussion Closes.
"Continuous Beams of Unequal Spans."	F. S. Bailey.	Oct.	Dec. 10.

Reprints from this publication, which is copyrighted, may be made provided full credit is given to the author and the Society.

Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETING.

BOSTON, October 17, 1917. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8 o'clock by Vice-President Lewis M. Hastings.

There were 75 members and visitors present.

The reading of the record of the last meeting was dispensed with, and it was approved as printed in the October JOURNAL.

The Secretary reported for the Board of Government that it had elected to membership in the grade of member, Messrs. Theodore Reed Kendall and Albert Joseph Leavitt.

The Secretary announced the death of Frank A. Pierce, a member of the Society, which occurred on August 7, 1917. By vote, the chair was requested to appoint a committee to prepare a memoir, and Mr. George A. King has been appointed.

The speaker of the evening, Mr. Henry I. Harriman, president of the New England Power Company, was then introduced. Mr. Harriman read a most interesting paper entitled "Water Powers of New England." The paper dealt not only with the water powers of the New England Power Company, but with other hydroelectric developments and economic questions that underlie their construction and utilization.

At the conclusion of the reading of the paper, Mr. Harriman had thrown on the screen a large number of pictures showing numerous hydroelectric plants already in operation and others during their construction, not only in the New England states but on the Pacific coast.

A general discussion followed, in which Messrs. Barrows, Porter, Stearns, Safford and others took part.

After passing a vote of thanks to Mr. Harriman for his courtesy in presenting before the Society his most interesting paper, the meeting adjourned.

S. E. Tinkham, *Secretary.*

APPLICATIONS FOR MEMBERSHIP.

[November 1, 1917.]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or

professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

BUNKER, PAGE SCRIBNER, Fitchburg, Mass. (Age 42, b. Menomonie, Wis.) Student for one year, 1892–3, at University of Wisconsin, and for one quarter, 1896, at University of Chicago; graduate of University of Montana, 1904. From 1900 to 1901, one and one-half years, with Northern Pacific Ry. Co.; from 1904 to 1905, with U. S. Dept. of Interior, General Land Office (Montana), on reconnaissance, supervision of timber cuttings, etc.; from 1905 to 1914, with U. S. Dept. of Agriculture, Forest Service (Montana), on surveying, map making, road construction, design and construction of bridges and buildings, etc.; from 1914 to 1917, superintendent of parks and forester with city of Fitchburg; is now on leave of absence as Captain, O. R. C., U. S. Army. Refers to G. H. Chase and E. E. Lothrop.

ROBINSON, ASHLEY QUINCY, Newton, Mass. (Age 24, b. Webster, Mass.) Educated in public schools and in office of father, Charles F. Robinson, C.E., Attleboro, Mass. From 1908 to 1912, rodman and transitman with C. F. Robinson; from 1912 to June, 1913, and from May to December, 1914, inspector on sewer construction with J. J. Van Valkenburgh; employed in same capacity by Metcalf & Eddy from August, 1913, to May, 1914; from December, 1914, to September, 1915, transitman and draftsman with C. F. Robinson; from September, 1915, to date, transitman and draftsman with Engineering Department, City of Newton. Elected a junior June 10, 1914, and now desires to be transferred to grade of member. Refers to I. W. Hastings, F. A. Marston, W. P. Morse, S. A. Nash, E. H. Rogers, J. J. Van Valkenburgh and J. P. Wentworth.

LIST OF MEMBERS.

CHANGES OF ADDRESS.

ALDEN, FREDERICK T. .... 75 Elm St., Malden, Mass.

BLAKE EDMUND M.,
Supervisor of Sub-Contracts, Aberthaw Construction Co., Squantum Destroyer Plant, Atlantic, Mass.

BROCK, NATHAN S. .... 208 Fuller St., Brookline, Mass.

BROWN, H. WHITTEMORE,
2d Lieut., E. O. R. C., 301st Engineers, Camp Devens, Ayer, Mass.

Burroughs, Russell . . . . B. & M. R. R., Nashua, N. H.
Carter, Frank H . . . . 14 Clifton St., Cliftondale, Mass.
Clapp, Sidney K . . . . Grand Gorge, N. Y.
Craigue, Joseph S.,
Capt., Engineer Corps, American Expeditionary Force, France
Crosier, Charles L . . . . Hilltop Y. M. C. A., Pittsburg, Pa.
Delano, Ray O . . . . B Co., 301st Engineers, Camp Devens, Ayer, Mass.
Farrell, Francis B . . . . 158 Walnut St., Springfield, Mass.
Flett, Louis E . . . . Worcester Y. M. C. A., Worcester, Mass.
French, Herman W . . . . Randolph, Mass.
Hannah, Thomas E . . . . 2d Lieut., C. A. C., Fort Monroe, Va.
Hurd, Stephen P . . . . 836 Cleveland Ave., Bridgeport, Conn.
Katz, Harry L . . . . 48 Mt. Vernon St., Cambridge, Mass.
McNulty, Richard J . . . . 23 Nottingham St., Dorchester, Mass.
Mills, Hiram F . . . . 314 Main St., South Hingham, Mass.
Nelson, William . . . . 37 Osborn St., Cambridge, Mass.
Porter, Arthur P . . . . care Stone & Webster, 147 Milk St., Boston, Mass.
Sawyer, George S . . . . 49 Oak Square Ave., Brighton, Mass.
Smith, William H . . . . 2101 Brookfield Ave., Baltimore, Md.
Whitney, Walter C . . . . 1907 15th St. N. W., Washington, D. C.

DEATH.

Johnson, William S . . . . October 27, 1917

EMPLOYMENT BUREAU.

The Board of Government has established an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

Men Available.

412. Age 34. Graduate of Mass. Inst. of Technology, 1906, civil engineering course. Experience includes about four years as rodman, draftsman, estimator and designer with Charles River Basin Commission, and about three years as draftsman and estimator with State Highway Commission; has passed civil service examination as assistant engineer; is familiar with recent practice in sewerage work. Salary desired, $30 per week.

413. Age 41. Received technical education at Mass. Inst. of Technology. Has had eighteen years' experience on design and construction of street railways, water works, conduits, buildings and tunnels, including seven years as engineer of maintenance of way with street railway company on track, overhead lines and structures, and two years on water works. Desires position as superintendent of construction. Salary desired, $350 per month.

414. Age 28. Graduate of Harvard College, 1910, civil engineering course, specializing in railroad and hydraulic engineering. Experience consists of two years with N. Y., N. H. & H. R. R. on electrification work; one year on enlargement of hydroelectric development, design and construction work; six months on town and land court surveys; one year as safety inspector for insurance company on all kinds of construction work; and two years with Interstate Commerce Commission on railroad valuation, both field and office work. Desires position either on construction work or with large industrial concern, where technical education and experience are of value. Salary desired, $1 800 per year.

415. Age 21. Attended public and preparatory schools; student for two years at Middlebury College, Vt. Experience consists of work during vacations with engineering firm in Barre and Montpelier, Vt.

LIBRARY NOTES.

Recent Additions to the Library.

U. S. Government Reports.

Absorption of Methane and Other Gases by Coal. S. H. Katz.

Answers to Questions on Flotation of Ores. Oliver C. Ralston.

Carbon Monoxide Poisoning in Steel Industry. J. A. Watkins.

Coking of Illinois Coals. F. K. Ovitz.

Extraction of Gasoline from Natural Gas by Absorption Methods. George A. Burrell and others.

Increased Yield of Turpentine and Rosin from Double Chipping. A. W. Schorger.

Limits of Complete Inflammability of Mixtures of Mine Gases and of Industrial Gases with Air. George A. Burrell and Alfred W. Gauger.

Mechanical Properties of Woods Grown in United States. J. A. Newlin and Thomas R. C. Wilson.

State Highway Mileage and Expenditures for Calendar Year 1916.

Substitution of Other Materials for Wood. Rolf Thelen.

State Reports.

Massachusetts. Annual Report of Highway Commission for 1915.

Rhode Island. Annual Report of Public Utilities Commission for 1916.

Municipal Reports.

Altoona, Pa. Annual Report of Director of Accounts and Finance for 1916.

Chicago, Ill. City Manager Plan for Chicago, 1917.

New York, N. Y. Annual Report of Board of Water Supply for 1916.

New York, N. Y. Annual Report of Department of Plant and Structures for 1916.

New York, N. Y. Catskill Water Supply: General Description and Brief History, 1917.

New York, N. Y. Report on Main Drainage and Sewage Disposal of Area Tributary to Jamaica Bay, 1917.

Miscellaneous.

American Society of Mechanical Engineers. Transactions for 1916.

American Society of Municipal Improvements. Proceedings for 1912, 1914, 1915 and 1916.

Business Law for Engineers. C. Frank Allen. Gift of author.

Elements of Hydrology. Adolph F. Meyer.

Engineering for Masonry Dams. William Pitcher Creager.

Government Ownership of Public Utility Service Undertakings. Los Angeles, Cal., City Club.

Library Committee.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

Commonwealth of Massachusetts.—METROPOLITAN WATER AND SEWERAGE BOARD. — *Water Works.* — Work is in progress on a transmission line between the Wachusett and Sudbury power stations, and approximately one third of the wooden poles have been erected for a distance of about five miles and concrete foundations for two of the steel towers are in place.

METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.* — Work in progress: Section 98 and Section 102, Wellesley Extension, Deer Island Outfall Sewer.

METROPOLITAN PARK COMMISSION. — The following work is in progress:

Old Colony Parkway. — Construction of a temporary bridge across the Neponset River between Boston and Quincy.

BOSTON TRANSIT COMMISSION. — *Dorchester Tunnel.* — The following work is in progress:

Section F. The interior finish of the station and the construction of a prepayment surface station in Broadway for the interchange of passengers between surface cars and the tunnel.

Section G. Emergency exit at the pump-well, corner of Dorchester Ave. and West 5th St.; construction of bridge over the tracks of the New York, New Haven & Hartford R. R. Co. leading to the docks; ventilating chamber and emergency exit near West Seventh St.

Section J. The interior finish of the station and the construction of a surface station for the interchange of passengers between surface cars and the tunnel.

City of Boston. — PUBLIC WORKS DEPARTMENT, HIGHWAY DIVISION, PAVING SERVICE. — Work is in progress on the following streets:

SOUTH BOSTON.

Ralston St.,	from Dorchester Ave. to Old Colony Ave.	Macadam.

EAST BOSTON.

Neptune Rd.,	from Bennington St. to R. R.	Asphalt.
Gove St.,	from Cottage St. to Venice St.	Topeka.
Maverick Sq.,	from Summer St. to Maverick St.	Asphalt.

BRIGHTON.

South St.,	from Commonwealth Ave. to Chestnut Hill.	Asphalt.
Brighton Ave.,	from Commonwealth Ave. to Cambridge St.	Asphalt.
Langley Rd.,	from Breck Ave., easterly.	Asphalt.
Breck Ave.,	from Washington St. to Langley Rd.	Bituminous macadam.

WEST ROXBURY.

Richwood St.,	from Centre St. to Montview St.	Asphalt.
Brown Ave.,	from Poplar St. to Blakemore St.	Artificial walks.
Paul Gore St.,	from Number 12 to Chestnut Ave.	Artificial walks.
Ridge St.,	from Brown Ave. to Sycamore St.	Artificial walks.

DORCHESTER.

Hilltop St.,	from Granite Ave. to Hallett St.	Bituminous macadam.
Dorchester Ave.,	from Savin Hill Ave. to Freeport St.	Granite blocks.
Dorchester Ave.,	from Peabody Sq. to Washington St.	Granite blocks.
Dorchester Ave.,	from Freeport St. to Park St.	Granite blocks.
Norfolk St.,	from Corbett St. to Blue Hill Ave.	Asphalt.
King St.,	from Adams St. to Neponset Ave.	Artificial walks.
Adams St.,	from King Sq. to Ashmont St.	Artificial walks.
Adams St.,	from Codman St. to Richmond St.	Artificial walks.
Romsey St.,	from Dorchester Ave. to Sydney St.	Artificial walks.

ROXBURY.

Lamartine St.,	from Boylston St. to Green St.	Artificial walks.
Wensley St.,	from Bucknam St. to Bickford St.	Bituminous macadam.
Overland St.,	from Brookline Ave. to B. & A. R. R. bridge.	Granite blocks.
Pontiac St.,	from Tremont St. to Hillside St.	Bituminous macadam.

CITY PROPER.

Beacon St.,	from Tremont St. to Charles St.	Granite block.
Blossom St.,	from Allen St. to Fruit St.	Asphalt.
North Russell St.,	from Cambridge St. to Eaton St.	Asphalt.
Washington St.,	from Court Ave. to Beach St.	Wood block.
Hanover St.,	from Court St. to Commercial St.	Artificial walks.

New York, New Haven & Hartford R. R. Co. — *South Boston Cut Improvement.* — Enlargement of South Boston cut to Boston Freight Terminal to accommodate four tracks instead of two, and reconstruction of eleven overhead highway bridges, so as to span four tracks instead of two, progressing.

Steam shovel and gravel train have started work at the westerly end, and have advanced to West 6th Street excavating for additional tracks.

Vol. IV DECEMBER, 1917 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, DECEMBER 19, 1917,

at 7.45 o'clock P.M., in the large LECTURE HALL, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.

Business of the Meeting. — To act on the amendment to By-Law 5, adopted at the November meeting and printed in the November number of the JOURNAL.

The subject of the papers and talks for the meeting will be, "Structural Features of the New Technology Buildings."

"Foundations," by Charles T. Main.

"Theoretical Design," by Sanford E. Thompson.

"Construction," by representatives of the Stone & Webster Engineering Corporation.

The lantern will be used.

The Committee on Social Activities will arrange for an inspection of the new buildings in the afternoon and for a supper at the Walker Memorial.

A special notice, giving further details, will be sent out later.

S. E. TINKHAM, *Secretary.*

PAPERS IN THIS NUMBER.

"Russia, — An Opportunity for American Engineers." George C. Whipple.

"Water Powers of New England." Henry I. Harriman.

Memoirs of Deceased Members.

CURRENT DISCUSSION.

Paper.	Author.	Published.	Discussion Closes.
"Lines and Grades in Tunnels of Small Diameter."	H. B. Pratt.	Nov.	Jan. 10.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, November 21, 1917. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 7.50 o'clock by the President, George C. Whipple.

There were 107 members and visitors present.

The record of the last meeting was read and approved.

The Secretary reported for the Board of Government that it had elected to membership in the grade of Member, Mr. Page Scribner Bunker; and in the grade of Junior, Messrs. Elmer Forest Allen, William Lohmeyer, Jr., and Edward Pierce Wells.

The Secretary presented and read the memoir of Past-President Joseph P. Davis, prepared by a committee consisting of Messrs. Frederic P. Stearns and Edward W. Howe. He also presented the memoir of Harold Parker, prepared by a committee consisting of Arthur W. Dean and William E. McClintock. Both memoirs were accepted and ordered printed in the JOURNAL.

The President announced the death of William S. Johnson, a member of the Society, which occurred on October 27, 1917, and by vote the President was requested to appoint a committee to prepare a memoir. Mr. X. Henry Goodnough has been appointed as this committee.

Mr. John E. Carty proposed an amendment to By-Law 5,

which had been printed with the notice of the meeting in the November, 1917, number of the JOURNAL, and moved its adoption in substitution for the present By-Law 5.

A discussion followed which was interrupted by the expiration of the time allowed for business under the By-Laws. At the close of the literary exercises, discussion of the proposed amendment was resumed. The following took part in the discussion: Messrs. J. E. Carty, F. B. Sanborn, S. H. Thorndike, R. E. Curtis, C. R. Gow, Frederick Brooks and H. P. Eddy. On a vote being taken, 58 members voted in favor of the adoption of the amendment and none against. The President stated that, under the By-Laws, the amendment would come up for final action at the next meeting.

For the literary exercises of the evening, the President, Prof. George C. Whipple, gave an extremely interesting informal talk about his journey to Russia as a member of the American Red Cross Mission.

At about ten o'clock the meeting adjourned.

S. E. TINKHAM, *Secretary.*

BOSTON, MASS., November 7, 1917. — The Sanitary Section of the Boston Society of Civil Engineers met in the Society rooms at 7.50 P.M., on Wednesday, November 7, 1917.

On motion of Professor Sanborn, Henry A. Varney was chosen Acting Clerk, to fill the unexpired term of Mr. Arthur D. Weston.

Major Glenn I. Jones, medical officer of the Base Hospital, Camp Devens, Ayer, Mass., discussed the course taken and the work done at the Camp during construction, to safeguard the health of the workmen.

Messrs. Barbour, Whipple and Allen also spoke on the same subject.

Thirty-seven members and visitors were present.

HENRY A. VARNEY, *Acting Clerk.*

APPLICATIONS FOR MEMBERSHIP.

[December 8, 1917.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

FOSTER, CLARANCE LESTER, Somerville, Mass. (Age 31, b. Pembroke, Mass.) Graduate of Cambridge Manual Training School; took special course in civil engineering at Boston Y. M. C. A., in mathematics at Tufts College, and in supervision at New York University. Draftsman with New England Structural Co. for period of four years, also for several summers; draftsman at G. W. & F. Smith's Iron Works and head draftsman with Builders' Iron and Steel Co. for a short time; has also worked for Berlin (Conn.) Construction Co. and was with Boston Elevated Railway Co. during one summer; taught drawing for several years in day and evening high school; during past year and a half has been representing Stone & Webster Engrg. Corp'n in territory east of Springfield, inspecting and expediting all classes of material, running tests, etc. Refers to E. W. Bailey, L. S. Cowles, C. M. Durgin, E. M. Moses, J. C. Moses, W. N. Patten and Daniel Scouler, Jr.

GILLETT, LAURENCE ARNOLD, Newburyport, Mass. (Age 20, b. Newburyport, Mass.) Is fourth-year student at Mass. Inst. of Technology, sanitary engineering course. Refers to A. E. Burton, G. L. Hosmer, J. W. Howard, Dwight Porter, A. G. Robbins and G. C. Whipple.

JONES, PUSEY, Cambridge, Mass. (Age 37, b. Wilmington, Del.) Graduate of Delaware State College, 1902, civil engineering course. From June, 1902, to July, 1903, rodman with Pennsylvania R. R.; from July, 1903,

to June, 1905, assistant engineer in charge of topographic surveys with Du Pont Powder Co.; from 1905 to 1910, structural draftsman with New York, Westchester & Boston Ry.; from 1910 to April, 1912, assistant structural engineer with N. Y., W. & B. Ry.; from April, 1912, to January, 1913, principal assistant engineer on design and construction of trestles and bridges for Georgia Coast & Piedmont R. R., Brunswick, Ga., and from January, 1913, to May, 1914, chief engineer on same work; from July, 1914, to April, 1916, member of Atlantic Engineering Co., Savannah, Ga., work consisting chiefly of bridge and lock construction; from April, 1916, to June, 1917, chief structural draftsman in charge of design of all classes of railroad structures for B. & M. R. R.; from June, 1917, to date, acting engineer of structures, B. & M. R. R. Refers to A. B. Corthell, D. N. Peaslee, F. C. Shepherd and S. P. Waldron.

LIST OF MEMBERS.

ADDITIONS.

LEAVITT, ALBERT J. 23 Montvale St., Roslindale, Mass.
LOHMEYER, WILLIAM, Jr.,
2d Lieut., Corps of Engrs., Barrack 47, McClellan Ave., Ft. Leavenworth, Kan.

CHANGES OF ADDRESS.

BOWERS, GEORGE W. . . . . care A. Bensley Sons Co., Jacksonville, Fla.
BROWN, WILLIAM AUGUSTINE . . . . 87 Homer St., East Boston, Mass.
CHASE, HORACE H. . . . . 206 Spring St., Brockton, Mass.
CLARK, CHARLES S. . . . . Laconia Car Co., Laconia, N. H.
JOHNSON, FRANK W.,
care American International Shipbuilding Corp., Hog Island, Pa.
KATZ, HARRY L. 48 Mt. Auburn St., Cambridge, Mass.
MOORE, CHESTER A. . . . . 6 Main St., Rockport, Mass.
SCOULER, DANIEL, Jr., care Port Arthur Shipbuilding Co., Port Arthur, Ont.
SOKOLL, JACOB M. . . . . 327 West Delavan Ave., Buffalo, N. Y.
SPALDING, FREDERIC P. . . . . 602 City Hall Annex, Boston, Mass.
SPEAR, WALTER E. . . . . Major, Quartermaster Corps,
care Camp Quartermaster, Camp Upton, L. I., N. Y.
STROUT, HENRY E., Jr. . . . . Fort Leavenworth, Kan.
SUTHERLAND, REYNOLD H. . . . . 157 Ocean St., Lynn, Mass.
THOMAS, HOWARD C. . . . . 34 Floral St., Newton Highlands, Mass.
VAN DER PYL, EDWARD . . . . care Donora Wire Works, Donora, Pa.
WINSLOW, FREDERIC I. . . . . 66 Bloomfield St., Dorchester, Mass.
WOOD, CARL W. . . . . 147 Mills St., Boston, Mass.
YOUNG, ERVING M. . . . . care Supervising Engineer, Camp Meade, Md.

LIBRARY NOTES.

Book Review.

Business Law for Engineers, by C. Frank Allen, M. Am. Soc. C. E., member Massachusetts Bar, M. Am. Railway Eng. Assoc. Part I, Elements of Law for Engineers; Part II, Contract Letting. New York: McGraw-Hill Book Co., Inc. London: Hill Publishing Co., Ltd. Cloth, 6 x 9 in.; pp. 494. $3.00.

Reviewed by Alfred D. Flinn.

Reviewing Professor Allen's book has been pleasurable as well as profitable, because of the clear, compact style and the logical sequence of arrangement. Never before has the reviewer read so lucid and instructive a summary of the fundamentals of American law and its practice. In Part I the selection of topics is amply broad, and the matter given under each topic sufficient to meet the needs of an engineer in the practice of his profession and in all ordinary business transactions. Frequently the author points out where it is wise and where necessary for an engineer to seek the professional services of a lawyer, and in other places indicates that engineering knowledge of the situation should dominate or guide the legal handling of the case. Throughout Part I the basic principles or theories of the law on the points under discussion are made plain, often by adverting to the historical origin of a practice or precept and tracing the development of the idea. Such presentation helps to make the reasonableness of the law appear even in some cases that have seemed arbitrary to the layman, and is helpful to intelligent control of professional and business conduct or the right choice of procedure when legal action must be taken.

Incidentally to summarizing the law, some wholesome suggestions as to engineering practice are dropped.

"Following the principle underlying the Common Law, that stability is a prime necessity, it would add much to the dignity and respect accorded to the profession of engineering, to the engineer and surveyor, if greater stability was secured from their work. A boundary line once reasonably fixed by one surveyor should be held to by another surveyor unless

definitely found to be in error. In other directions, unnecessary disagreements should be avoided, and, so far as reasonable, engineering should be recognized as fixed and definite in its principles. The entire profession of engineering suffers when the work of a reputable engineer is unnecessarily attacked or held up to contempt."

Another suggestion deals with the "Importance of Clear Expression. It would be quite improper to leave the question of the interpretation of writings without making the suggestion that the engineer who has to do either with the production or interpretation of writings can have no better preparation than a thorough training in the clear expression of English and a critical analysis of its meaning. The school training must be supplemented by systematic work in this direction." Engineers are the authors of many documents on which action is based and by which it is guided, often affecting the security of life or the safety of property of great value, demanding, therefore, statement so clear as to eliminate reasonable question of meaning.

Part II discusses in order the documents which commonly are comprised in the book or pamphlet of an engineering contract for large work: Information for Bidders, Proposal, Contract Form, Bond and Specifications. The last two are dealt with very briefly. Under Specifications the endeavor is made to indicate what is proper subject matter and what belongs in the agreement, or contract proper, or in the Information for Bidders, and to suggest proper forms and suitable methods of expression.

"Clearness of description is of the utmost importance. For this a clear vision of what is wanted is the first requisite. To this must be added sufficient ability in the use of language to make clear to others what the engineer sees clearly. An able contractor has stated that his training in descriptive geometry was of great value to him because it permitted him to visualize a piece of work."

Logical arrangement is shown to be of great importance. Some of the discussions under this heading, however, particularly that relating to borings and other preliminary examinations of the sites of works, might have been put more appropriately under Information for Bidders.

The "Uniform Contract Form" of the American Railway Engineering Association is used as the basis for the discussion of the agreement, or contract proper, and with the following chapter on "Additional Contract Forms" constitutes the greater portion of Part II. Numerous quotations are made from contract forms which have been used by various companies and municipalities. The value of these quotations would be enhanced if their identity were disclosed and the magnitude, character and location of the works at least very briefly outlined. This might be accomplished in another edition by suitable, suggestive abbreviations after each such quotation and a short chapter of condensed explanations.

Good typography and a binding similar to that standard for law books give the book an attractive appearance. It is noticeably free from errors of proofreading. The book should prove useful to many engineers and to men of other pursuits also.

Recent Additions to the Library.

U. S. Government Reports

Deterioration in Heating Value of Coal during Storage. Horace C. Porter and F. K. Ovitz.

Emergency Fuel from Farm Woodland. A. F. Hawes.

Experimental Roads in Vicinity of Washington, D. C. B. A. Anderton and J. T. Pauls.

Method for Measuring Viscosity of Blast-Furnace Slag at High Temperatures. Alexander L. Feild.

Production of Explosives in United States during Calendar Year 1916. Albert H. Fay.

Red Spruce: Its Growth and Management. Louis S. Murphy.

Results of Magnetic Observations Made by United States Coast and Geodetic Survey in 1916. Daniel L. Hazard.

Safe Practice at Blast Furnaces. Frederick H. Willcox.

Underground Wastes in Oil and Gas Fields, and Methods of Prevention. William F. McMurray and James O. Lewis.

Use of Mud-Laden Fluid in Oil and Gas Wells. James O. Lewis and William F. McMurray.

Yearbook of Bureau of Mines, 1916. Van. H. Manning.

State Reports.

Massachusetts. Report on Improvement of Upper Mystic River and Alewife Brook by Means of Tide Gates and Large Drainage Channels. John R. Freeman. 1904.

Michigan. Report of State Board of Health on Water Chlorination, 1917.

Michigan. Report of State Board of Health on Water Filtration, 1917.

Ohio. Report of State Board of Health for Six Months ending June 30, 1915.

City and Town Reports.

Chicago, Ill. Report of Bureau of Public Efficiency on Primary Days and Election Days as Holidays.

Cleveland, Ohio. Report on Tests at Sewage Testing Station, 1914.

New York, N. Y. Building Code, Borough of Manhattan, 1917.

New York, N. Y. Report of Bureau of Buildings for 1915.

New York, N. Y. Contract, Specifications, etc., for Construction of Shandaken Tunnel, 1917.

Newton, Mass. Annual Report of Street Commissioner for 1916.

Miscellaneous.

American Institute of Mining Engineers: Transactions for 1916, Vol. LV.

Boston Elevated Railway Company: Satisfactory Service and Sound Securities. M. C. Brush.

Canada, Department of Mines: Mining of Thin-Coal Seams as Applied to Eastern Coal-Fields of Canada, by J. F. Kellock Brown; Test of Some Canadian Sandstones to Determine Their Suitability as Pulpstones, by L. Heber Cole.

Inspection of Screw Gauges for Munitions of War. H. J. Bingham Powell, Inspector in Charge, Department of Gauges and Standards, British Ministry of Munitions of War in United States. Gift of author.

Street Lighting Rates in City of Boston: Hearing before Massachusetts Board of Gas and Electric Light Commissioners: Brief in Behalf of City; Brief for Edison Electric Illuminating Company of Boston. Gift of H. S. Knowlton.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before 1st of each month.)

Commonwealth of Massachusetts.—METROPOLITAN WATER AND SEWERAGE BOARD.—*Water Works.*—Work on high-tension transmission line between the Wachusett and Sudbury power stations is in progress. The poles are erected for a distance of about 12 miles out of the total of 15.5 miles, and the concrete foundations are in place for 9 out of the 14 steel towers.

The steam turbine has been delivered at the Arlington pumping station, and the concrete foundation is in place for the new centrifugal pumping unit at this station.

METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.* — Work in progress: Section 98 and Section 102, Wellesley Extension.

METROPOLITAN PARK COMMISSION. — *Old Colony Parkway.* — Construction of a temporary bridge across the Neponset River between Boston and Quincy is in progress; also construction of double siphon for water and gas under new channel.

BOSTON TRANSIT COMMISSION. — *Dorchester Tunnel.* — The interior finish of Broadway Station is about completed.

Work is progressing on the interior finish of the station at Andrew Sq., and work is in progrsss on the station for transfer of passengers from the surface cars to the tunnel below. This station is about 115 ft. in width and will have three platforms, and extends from Dorchester Ave. to Ellery St., a distance of about 300 ft.

City of Boston. — Public Works Department, Highway Division, Paving Service. — Work is in progress on the following streets:

	South Boston.	
Ralston St.,	Dorchester Ave. to Old Colony Ave.	Bituminous macadam.
Alger St.,	Dorchester Ave. to Railroad.	Filling.
	East Boston.	
Neptune Rd.,	Bennington St. to Railroad.	Asphalt.
Gove St.,	Cottage St. to Venice St.	Topeka.
Maverick Sq.,	Summer St. to Maverick St.	Asphalt.
	Brighton.	
Brighton Ave.,	Commonwealth Ave. to Cambridge St.	Asphalt.
Langley Rd.,	Breck Ave. easterly.	Bituminous macadam.
N. Beacon St.,	Cambridge St. to Market St.	Asphalt.
Breck Ave.,	Washington St. to Langley Rd.	Bituminous macadam.
	West Roxbury.	
Ridge St.,	Brown Ave. to Sycamore St.	Artificial walks.
Brookside Ave.,	Boylston St. to Green St.	Artificial walks.
Sycamore St.,	Brown Ave. to Canterbury St.	Artificial walks.
	Dorchester.	
Dorchester Ave.,	Savin Hill Ave. to Freeport St.	Granite block.
Dorchester Ave.,	Peabody Sq. to Washington St.	Granite block.
Dorchester Ave.,	Freeport St. to Park St.	Granite block.
Norfolk St.,	Corbet St. to Blue Hill Ave.	Asphalt.
Richwood St.,	Centre St. to Montview St.	Asphalt.
	Roxbury.	
Museum Rd.,	Huntington Ave. to Fenway.	Topeka.
Overland St.,	Brookline Ave. to B. & A. R. R. bridge.	Granite block.
Pontiac St.,	Tremont St. to Hillside St.	Bituminous macadam.
Beacon St.,	Raleigh St. to railroad bridge.	Asphalt.
Albany St.,	Concord St. to Northampton St.	Wood block.
	City Proper.	
Hanover St.,	Court St. to Commercial St.	Artificial walks.
Atlantic Ave.,	Summer St. to beyond Congress St.	Artificial walks.
Harrison Ave.,	Dover St. to Kneeland St.	Granite block.
Tremont St.,	Eliot St. to Common St.	Sidewalks.

New York, New Haven & Hartford R. R. Co. — *South Boston Cut Improvement.* — Enlargement of South Boston Cut to Boston Freight Terminal, to accommodate four tracks instead of two, and reconstruction of eleven overhead highway bridges, so as to span four tracks instead of two, progressing.